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ORIGINAL ARTICLES.

I.—On Marekanite and its Allies.

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In almost every collection of minerals there may be found specimens of the curious little glassy balls, which, from the locality of their occurrence—the great Marekanka, near Okhotsk in Siberia—have received the name of *Marekanite*. These glassy balls are more or less perfectly rounded in form, they vary in their colour, through different shades of smoke-grey to orange-brown, while in size they range from the dimensions of a pea to those of a walnut. Most mineralogical treatises still continue to recognize Marekanite as a mineral, and class it either as a variety of Obsidian or of Pearlstone.

While totally disallowing the claim of Marekanite to rank as a mineral-species or even variety—the petrographer recognizes in this substance a type of rock, which proves to be by no means devoid of interest, when its properties are carefully studied, nor destitute of suggestiveness, when its mode of occurrence is thoughtfully considered.

Occurring as it does on a spot frequently visited by travellers, the appearance and surroundings of Marekanite have been very fully described; among others by Steller, Laxman, Allegretti and Pallas; it was the last-mentioned naturalist who appears to have made the rock widely known by sending specimens from St. Petersburgh to most of the Museums of Europe.

The first mineralogist who seems to have expressed an opinion on the *nature* of Marekanite was Sewergin, who in 1796 described it as a "Glasszeolite."[1] To this conclusion he was probably led by studying its behaviour with the blowpipe.

Lowitz and Gmelin made analyses of the substance,[2] and these, though very imperfect, as might be expected from the early date at which they were undertaken, showed the rock to contain a very high percentage of silica with some alumina and a small proportion of the alkalies and alkaline earths.

The author to whom we are however indebted for most of our knowledge of the properties of this curious substance is Klaproth,

[1] Nova Acta Acad. Petropol. T. xii. (1801) p. 237.
[2] Neue Nord Beitrag, vol. ii. p. 299.

whose memoir entitled "Chemische Untersuchung des Marekanits"[1] was read before the Berlin Academy on the 15th May, 1812.

Klaproth showed that the Marekanite-balls were sometimes almost colourless and translucent, at others dark-coloured and opaque; the former he found to have a specific gravity of 2·365, the latter of 2·335. The composition of the two varieties he determined to be as follows:—

	Transparent Variety.		Opaque Variety.
Silica	81·00	.....	76·50
Alumina	9·50	.....	10·50
Lime	0·43	.....	0·50
Iron Oxide	0·60	.....	1·00
Potash	2·70	.....	2·70
Soda	4·50	.....	4·50
Undetermined constituent	—	.....	2·50
Water	0·50	.....	0·50
	99·13		98·70

No more recent analyses of the rock would seem to have been published. Klaproth further showed that while many of these glass balls resist a tolerably smart blow with a hammer, yet when they do yield they break up into a mass of fine particles, like unannealed or toughened glass. He noticed, too, their singular behaviour when heated, which will be described in the sequel.

Klaproth's analyses show that Marekanite is an obsidian, and if his separation of the soda and potash can be relied upon, which is doubtful, we might conclude that it is a dacite- or quartz-andesite-glass rather than a rhyolite- or quartz-trachyte-glass.

With the exception of some observations by Erman[2] and Herter,[3] but little seems to have been added to our knowledge of Marekanite since the time of Klaproth.

Professor Bonney informs me that the late Professor W. H. Miller, of Cambridge, told him that Marekanite-balls had been known to explode spontaneously. Mr. J. Gregory some time ago communicated to me the interesting fact that a lapidary who had attempted to cut a section of a Marekanite-ball found that during the operation it flew to pieces with a slight explosion. Kalkowsky states that many of the Marekanite-nodules, when struck with a hammer, decrepitate to dust.[4]

In these characters the balls of Marekanite appear to present so many points of resemblance with the well-known "Rupert's drops" that I thought it would be of interest to make a fuller comparison of the natural and artificial substances.

In the first place, the more transparent varieties of Marekanite, when examined between crossed Nicols, were found to depolarize the light in a very striking manner, giving rise to the well-known appearance presented by unannealed glass or glass when subjected to mechanical strain. Compared with the appearances presented by

[1] Berlin Abhandl. Physikal Klasse (1812—13), pp. 49—58.
[2] Archiv. f. d. Wissensch. Kunde von Russl. iii. (1843), p. 175.
[3] Zeitschr. d. d. Geolog. Ges. xv. (1863), p. 459.
[4] "Elemente der Lithologie" (1886), p. 80.

transparent Rupert's drops between crossed Nicols, the Marekanite was found to be precisely similar in its behaviour.

In the second place, ten nodules of Marekanite, varying in size and colour, were selected for cutting by the lapidaries' wheel; and their behaviour, carefully watched, was as follows:—

One, the largest, was cut through without undergoing fracture.

Six, while being cut, had one or more cracks developed in them, and the formation of these cracks was accompanied by distinctly audible, snapping sounds.

In the remaining *three* cases, snapping sounds were heard from time to time while the cutting was taking place, and when the mass was nearly cut through, a distinct explosion occurred, the fragments being thrown to the distance of several yards.

In the case of two Rupert's drops, treated in precisely the same manner, it was found that before the saw had passed half through them, an explosion occurred, which was more violent than that accompanying the breaking up of the Marekanite-nodules. These facts point to the conclusion that the glass of the Marekanite-balls is *in a condition of intense strain*, in some cases approaching that which characterizes the Rupert's drops.

In the case of both the Rupert's drops and the Marekanite-balls, the portion left embedded in the cement after the explosion was found to be traversed by a system of radial cracks, and on the attempt being made to grind them they fell to pieces. The fine splinters into which the Marekanite-balls broke up were found, when examined by the microscope, to be quite similar to those derived from the Rupert's drops. Acting upon a suggestion made to me by my colleague, Prof. F. Guthrie, F.R.S., I annealed some of the Marekanite-balls by heating and slowly cooling them. They were then found to have lost their power of depolarizing light, and were easily cut and ground into thin sections.

I must now proceed to describe another set of remarkable phenomena—those namely which are exhibited by the Marekanite-nodules when they are heated.

If one of the balls be subjected to a gas-jet, blown by a moderately strong air-current, it will be seen that, as redness is approached, thin films of glass detach themselves from the surface of the ball and these films are successively broken up into fine particles, so that there is maintained a constant dispersal of excessively minute glassy dust, which is thrown to a considerable distance. If the temperature be now raised to whiteness, the whole mass swells up in cauliflower-like excrescences, till it has attained eight or ten times its original bulk. The resulting white mass is found to be a true pumice, which floats upon water, and microscopic sections of it are indeed quite undistinguishable in appearance from many natural pumices. Some of the Marekanite-balls, however, exhibit this property in a much more striking manner than do others.

These experiments prove that the quantity of volatile ingredients in these Marekanite-balls is very great, sufficient indeed, on being liberated by heat, to convert the obsidian into a pumice. Herter

states that Marekanite loses on ignition from one to four per cent. of its weight.

The last point to which I have to direct attention with respect to Marekanite is its microscopic structure. This is found to differ in a remarkable degree in the several varieties.

Some of the Marekanite-balls are almost colourless and perfectly translucent. These, as pointed out by Zirkel,[1] are among the purest of natural glasses, and are comparable to Fulgurite and Boutellenstein.[2] From these translucent varieties we found every gradation to the more opaque types which are of deep smoke-grey and orange-brown tints, their opacity being evidently due to primary devitrification.

Porphyritic crystals are rare, and of small size in Marekanite. Those observed appear to be referable to hornblende, magnetite, and a brown mica. Black trichites and reddish or yellowish-brown globulites abound, the latter being usually drawn out by the movement of the glass into cloud-like wisps, and the rock being very distinctly banded by the disposition of these in the mass.[3] In many cases the commencement of a pumiceous structure is exhibited through the abundance of cavities drawn out in the direction of the flow. The Marekanite-nodules exhibit all the characters of a volcanic glass undergoing incipient devitrification and exhibiting flow structure, with occasionally the beginnings of pumiceous distension.

Now the peculiar characters of Marekanite seem to be capable of simple explanation when we take into account its mode of occurrence, which has been so clearly described by Erman and other writers.[4]

According to the information supplied from these different sources, there occurs in the district around Okhotsk a considerable tract of highly acid, igneous rock (rhyolite or quartz-andesite), which is sometimes vesicular, at other times compact, and appears to be sometimes intrusive in strata containing Devonian plants. This rock is generally stony in texture, but sometimes passes into "hornstone-like" varieties; while locally, as on the banks of the great Marekanka brook, it assumes a more or less pefectly glassy condition. At the locality mentioned, the igneous mass forms a cliff between 200 and 300 feet in height, the rock varying in colour from snow-white to reddish-brown, and its different varieties constituting wavy bands, which, as is so commonly the case with the vitreous lavas, simulate the appearances presented by many crumpled, foliated rocks.[5] This banded, glassy rock is seen to be traversed by numerous concentric joints, so that globular masses breaking up like onions accumulate in immense numbers at the foot of the cliff, forming a talus which reaches half-way to its top. The nuclei of these concentric masses,

[1] Mikroskop. Beschaff. der Mineralien und Gesteine (1873), p. 351.

[2] *See* Wichmann, Zeitsch. d. d. Geol. Ges. xxxv. p. 849; Diller, Amer. Journ. Sc. xxviii. p. 252; Rutley, Quart. Journ. Geol. Soc. vol. xli. (1885), p. 152.

[3] Compare Zirkel, Mikroskop. Beschaff. der Mineralien und Gesteine (1873), p. 361.

[4] Erman, Archiv. f. d. Wissensch. Kunde Russlands, iii. (1843), p. 175; Herter, Zeitsch. d. d. Geol. Ges. xv. (1863), p. 459.

[5] See Geol. Mag. Dec. II. Vol. II. pp. 68 and 69, Fig. 9.

which vary in size from a pea to a fist, constitute the well-known bodies usually called Marekanite.

A number of rocks have been described from other localities, which in their peculiar characters or mode of occurrence appear to closely resemble Marekanite.

In 1844 Damour gave an account of a specimen of obsidian,[1] which was said to have been obtained from India, though its locality could not be more precisely determined. It was spheroidal in form, and about $2\frac{1}{3}$ inches in diameter; its colour was black by reflected light and bottle-green by transmitted light, and it had a specific gravity of 2·47. Unlike Marekanite, it was found to melt slowly without expansion, and to form a colourless glass. This ball of obsidian, while being cut by a lapidary, was found, when sawn through to the extent of nearly two-thirds of its diameter, to emit a kind of hissing sound, and this was followed by a strong detonation, the mass being at the same time broken up into fragments, which were thrown in all directions with considerable violence. The fragments when collected were found to show a radiated structure like that seen in the Marcasite-nodules of the Chalk.

The obsidian described by Damour was found by him to have the following composition, so that it must be regarded as a dacite-glass.

Silica	70·34
Alumina	8·63
Ferrous oxide	10·52
Manganous oxide	0·32
Lime	4·56
Magnesia	1·67
Soda	3·34
	99·38

It is said not to have lost weight on ignition.

In 1824 the late Mr. Poulett Scrope described[2] an interesting vein of green, porphyritic pitchstone with contorted banding, which occurs at the Chiaja di Luna in the Island of Ponza; he showed that the rock is made up of columns, each of which incloses a number of globiform masses that break up concentrically like gigantic onions. Mr. Scrope's drawing of this remarkable rock-mass is reproduced in the accompanying woodcut (see page 246).

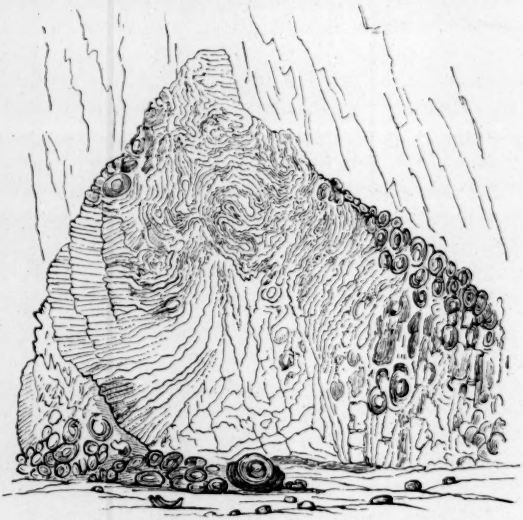
In 1874 I had an opportunity of visiting this very interesting spot, and noticed a remarkable property exhibited by this green rock; when struck with a hammer, it broke up with curved planes of fracture parallel to the central nuclei; when freshly broken, the surfaces showed a perfectly vitreous lustre, but within a few seconds a most remarkable change was seen to take place over the glassy surfaces thus exposed. They appeared as though breathed upon and were gradually overspread by a whitish film, that looked like the bloom upon a peach; this white film was found to be permanent, and in

[1] Comptes rendus, vol. xviii. (1844), p. 46.

[2] Trans. Geol. Soc. 2nd ser. vol. ii. p. 205, plate 24. See also Volcanoes, 2nd ed. p. 105.

consequence of its presence, specimens of the rock exhibit not the vitreous lustre of obsidian, but the duller lustre of pitchstone.[1]

At the time when I made this observation, I thought that the remarkable change in the surface of the rock might be due to chemical action, and was the result of some kind of exudation on the freshly-formed surfaces. But subsequent study of the surfaces with the microscope, and discussion of the case with others, including Prof. Bonney and also Dr. Guthrie, who has paid much attention to the subject of the fracture of colloids,[2] has convinced me that the change is really *mechanical*, and one of a very peculiar kind.



Pitchstone Vein at Chiaja di Luna, Island of Ponza.

Experimenting with colloid substances, like plate-glass and Canada-balsam, I found that when relief from intense strain took place by the breaking of a mass which had been bent, till it could no longer resist the force applied, the fractured surfaces show a dull appearance, which under the microscope is seen to be caused by the wrinkling up of a thin film on the suddenly liberated surfaces. These cases differ from the one described from the Ponza Islands, in the circumstance of the appearance of the wrinkled film apparently *instantaneously*, instead of after an appreciable interval of time. But it is, I think, consistent with well-recognized physical principles that the recovery of particles from a condition of strain, which has been long maintained, should take place more slowly than that which follows from a strain of short duration.

The study of cases which we have been considering all point to the conclusion that, besides the local strains so well known to occur

[1] Geol. Mag. Dec. II. Vol. II. (1875), p. 308.
[2] See Phil. Mag. ser. 5, vol. viii. p. 25.

around the crystals in porphyritic glassy rocks, which have recently been discussed by Mr. Rutley[1] and Mr. Waller,[2] there are other conditions of tension which affect much larger masses of natural glass, and which are comparable in the degree of their manifestation to those which are exhibited by the well-known Rupert's drops.

This condition of tension appears to be manifested in two different ways. In the case of the Marekanite-balls, and the obsidian from India described by Damour, the molecules are in a state of such unstable equilibrium that a jar, or an incision, is sufficient to bring about that partial re-arrangement which leads to their breaking up with more or less explosive violence. But in the case of the Ponza rock, the relief of newly-formed surfaces from strain leads to the separation of a thin, more or less wrinkled, film. A connection between these two cases is perhaps established by the experiment of submitting the Marekanite-balls to moderate heat, when thin white films like those formed spontaneously on the surfaces of the Ponza rock are seen to make their appearance.

The study of the mode of occurrence of these different rocks shows that the condition of extreme tension belongs to the nuclei of perlitic masses. It has long been recognized that the perlitic structure is the result of contraction in a rock-mass, and in 1879 it was shown by MM. Fouqué and Levy,[3] and in 1880 independently by Mr. Grenville Cole,[4] that this structure could be produced in colloid bodies by artificial means.

It has long been known that some of the natural glasses contain a considerable amount of water and other volatile substances, up to as much, indeed, in some cases, as 10 per cent. of their whole weight. It has often been asserted that the presence of a large percentage of water is characteristic of pitchstones, and of a much smaller amount of the obsidians. But the perfectly vitreous Marekanite-balls show by their behaviour when heated that they contain a very large proportion of volatile matter, and other similar exceptions to the supposed rule might be adduced. It is probably true that volatile matters are more likely to be retained within masses which have cooled down while subjected to the pressure of superincumbent material; and under the same conditions, that slower cooling would take place, which would lead to the more abundant development of crystallites and the acquirement of the mass of the resinous lustre characteristic of pitchstone.

Now, so far as my experience goes, the glasses containing a large amount of volatile materials have an abnormally low specific gravity. If the water be slowly separated from the mass, it is scarcely conceivable but that contraction should take place and the density rise. The materials in which the perlitic structure has been artificially produced—namely, precipitated silica and Canada-balsam—both contain volatile matters, and it is during the gradual removal of these in drying that the perlitic structure is produced. The spirally-curved

[1] Quart. Journ. Geol. Soc. vol. xli. (1884), p. 340.
[2] Geol. Mag. Dec. III. Vol. II. (1885), p. 91.
[3] Mineralogie Micrographique (1879), pl. xix. fig. 2.
[4] Geol. Mag. Dec. II. Vol. VII. p. 115.

cracks seen on the surface of American cloth in railway-carriages can be accounted for in the same way.

These and many other facts, which I will not now adduce, have led me to the conclusion that while the first series of straight cracks, which often produce columnar structures in rocks, owe their origin to the contraction which takes place during cooling, the secondary systems of curved cracks, which give rise to the perlitic and similar structures, are more probably due to the contraction which goes on as the volatile materials which they contain are slowly separated from them. I hope to adduce some further illustrations of this principle on a future occasion.

II.—On Carboniferous Ostracoda from the Gayton Boring, Northamptonshire.

By Prof. T. Rupert Jones, F.R.S., and James W. Kirkby, Esq.

(PLATE VII.)

THE Carboniferous Ostracoda here described are from the deep Gayton Boring, near Northampton. Hand-specimens of the rock, obtained by H. J. Eunson, Esq., F.G.S., were given to us by R. Etheridge, Esq., F.R.S., some months ago; and Mr. Eunson kindly gave us another piece lately.

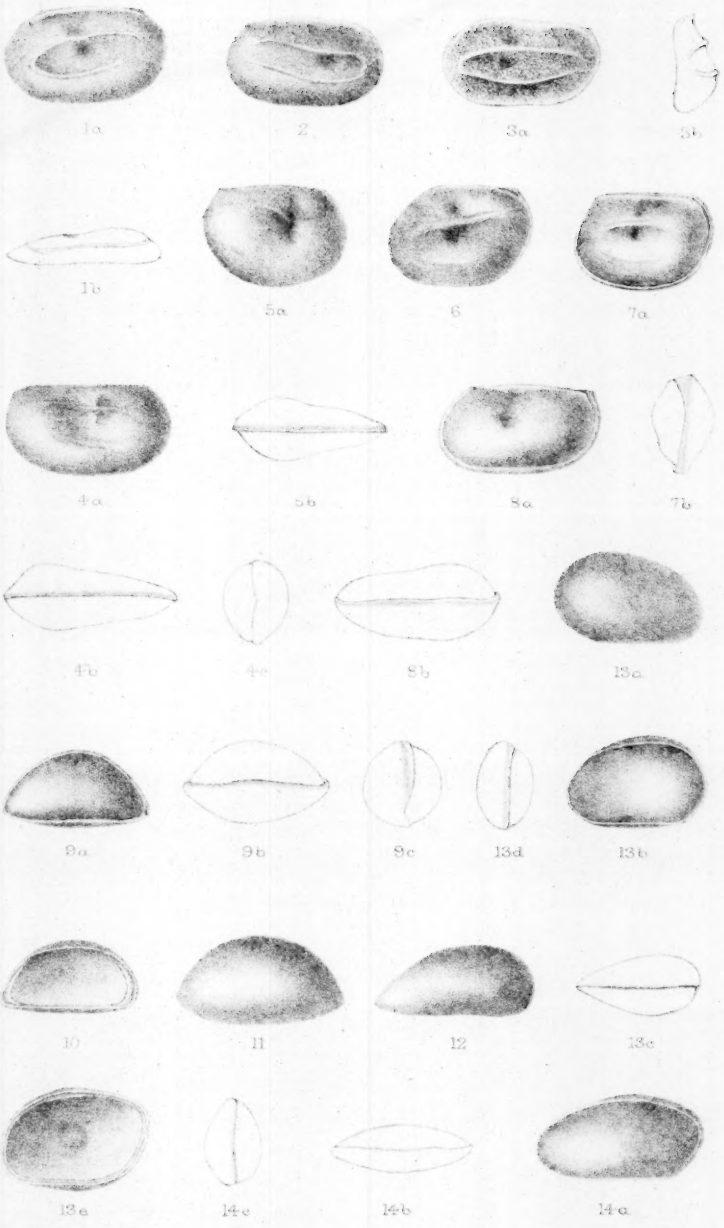
To explain the situation of the bore, as well as the position of the Carboniferous strata in it, we quote as follows from Mr. H. J. Eunson's paper "On the Palæozoic Rocks beneath Northampton," in the Quart. Journ. Geol. Soc. vol. xl. 1884, p. 485, etc.:

"The second trial took place near the village of Gayton, five miles south-west of Northampton, not far from the Banbury-lane crossing of the L. and N.-W. Railway, about two miles north-west of Blisworth Station (see Ordnance Map 52 S.W.). It was thought that, under the known attenuation of the Trias westward, the Waterstones could be found, if only the site selected was at a sufficient distance beyond the Carboniferous rocks to have allowed the lower beds of the Triassic series to be deposited near Northampton.

"This boring, 282 feet above sea-level, was commenced at the junction of the Upper with the Middle Lias, followed by the Lower Lias clays, the aggregate thickness of which was 581 feet."

The White Lias and Rhætic beds, 36 feet thick, are described as resting on a slightly eroded surface of the Triassic strata, which are 82 feet 6 inches thick. The lowest of these latter contained much *débris* of Carboniferous rocks. These last began, in the boring at 699 feet, with the eroded Carboniferous Limestone. From about 31 feet 6 inches lower down was brought up a bluish-grey shale; and from a little below that a greenish-grey shale. The former has yielded the little fossils here described. The latter contains similar Microzoa. The boring was continued into the Old Red Sandstone, and to a depth of 994 feet, without getting the supply of water sought for.

The minute specimens under notice were obtained for us by Mr. C. D. Sherborn by breaking and washing the rock in which they had been imbedded. There is a fair quantity of them,—certainly a few



J. W. K. del.
E. C. Knight lith.

West, Newman & Co. imp.

Carboniferous Ostracoda.

hundreds. The majority are single valves; and all of them are thick-shelled and have a robust appearance.

In the hand-specimens referred to we found—in the greenish-grey shale (at 731 feet), a few *Ostracoda*, and numerous fragments of calcareous organisms, chiefly of *Serpulæ*, some of Shells, and some possibly Encrinital:—in the bluish-grey shale (at 730 feet), many *Ostracoda*, besides numerous calcareous fragments as above.

In both shales the organic remains are crowded here and there along irregular planes and in other groups.

For the lists of fossils in the associated beds see Quart. Journ. Geol. Soc. Aug. 1884, pp. 487–8.

Remarks on the Species.

1. KIRKBYA VARIABILIS, sp. nov. Pl. VII. Figs. 4*a*, 4*b* (type); 5*a*, 5*b* (var. *a*); 6, 7*a*, 7*b* (var. *b*); 8*a*, 8*b* (var. *c*).

The prevailing form among this little group of Ostracods is a *Kirkbya* which has strong Beyrichian affinities. Some specimens of it are scarcely to be distinguished from such unisulcate species of *Beyrichia* as *B. arcuata* (Bean); but most examples show the valves ribbed after the fashion of *Kirkbya*, in which genus we place it.

It varies much in relative length and height; some specimens are nearly twice as long as high, others are only a fourth longer than high, while some, indeed, are nearly as high as long. What may be taken as the local typical form, being the most common, can be described thus:

Suboblong in outline, height rather more than half the length, dorsal border straight, ventral border convex, extremities rounded. The more compressed end, which we take as the anterior,[1] is more perfectly rounded than the posterior, which projects above, and is of less height than the other. Valves compressed in front, swollen behind, with a transverse subcentral sulcus; this is crossed by a strong longitudinal rib, which gives its lower portion the form of a subcentral pit; traces (more or less strong) of another and lower rib are usually present along the ventral convexity of the valve; and there is nearly always a narrow, sharp-edged rib near to, and almost parallel with, the dorsal margin. The valves are thick-shelled and the right is larger than the left, and overlaps it strongly along the ventral and extreme margins. Seen from above almost lanceolate in outline, with the greatest diameter behind. Surface smooth. Length $\frac{1}{30}$ to $\frac{1}{25}$ inch.

Var. *a*. Figs. 5*a*, 5*b*.

This is a shorter form, being only a fourth longer than high; with the ventral margin more convex, and with the posterior extremity much the highest. The sulcation and costal arrangement are the same, and the right valve overlaps the other, as in the type form.

Var. *b*. Figs. 6, 7*a*, 7*b*.

This variety is short and high, like that just noticed, but the

[1] This is the view we take now; but it was not followed throughout in a former paper on *Kirkbyæ*, Ann. Mag. N. H. March, 1885.

carapace is fully as high at one end as the other, the curve of the posterior extremity forming a more obtuse angle with the ventral margin, which is but slightly convex. The general outline is thus more subquadrate than in the others.

Var. *c*. Fig. 8.

This is very like *Beyrichia arcuata* (Bean) in appearance, and we were at first disposed to keep it apart from the present species, for it shows no indications of the two stout ribs along the centre of the valves, but it possesses the sharp dorsal rib or crest in full force. This latter feature, and similar ventral overlap by the right valve, together with the way in which the ribs become nearly obsolete in other examples of *variabilis*, cause us to group it with this species.

From the number of specimens of this species obtained from the shale of the boring, it would appear to have been of gregarious habit. Most of the specimens are single valves.

2. Kirkbya plicata, Jones and Kirkby. Plate VII. Figs. 1*a*, 1*b*, 2, 3*a*, 3*b*.

K. plicata, J. and K. 1867, Trans. Geol. Soc. Glasgow, vol. ii. p. 221.
K. plicata, J. and K. 1885, Ann. Mag. Nat. Hist. ser. 5, vol. xv. p. 184, pl. iii. fig. 9, 10*a*, *b*.

Valves of this species are not rare among the Gayton Ostracods. They differ a little from typical specimens; their outline is more nearly oblong, the dorsal and ventral margins being almost parallel, and the ends nearly alike. The two longitudinal ribs that traverse the central portion of the valve are well marked, slope upwards posteriorly, and are looped together forward (in most examples). The subcentral pit or constricted sulcus is deep and placed anteriorly. One of the specimens shows a finely reticulated surface; all the others we have examined are smooth. The shell is thick; and the length about $\frac{1}{25}$ inch.

K. plicata is not a common species. It was first found in Carboniferous Limestone, at Backwell, Charterhouse, and Weston-super-Mare, in Somerset. It has not been noticed elsewhere in England. In Scotland it occurs at various localities of the Calciferous-Sandstone Series; and very rarely in beds in the lower portion of the Carboniferous-Limestone Series.

3. Bythocypris sublunata, Jones and Kirkby, MS. Plate VII. Figs. 9*a*, 9*b*, 9*c*, 10, 11.

This is a species well known to us, though as yet undescribed. It was first sent us by Mr. James Bennie (Geological Survey of Scotland), in a washing of shale from Staneshiel Burn, Roxburghshire; also from another shale, at Tweeden Burn, in the same county. Both these localities are in the Calciferous-Sandstone Series. The species may be briefly described as follows:—

Carapace subtriangular or lunate in outline; tumid: with left valve overlapping the right all round. Dorsal margin boldly and almost evenly arched; ventral margin straight or slightly convex;

extremities pointed and nearly alike, though the posterior is rather the most acute; seen from above ovate, with the greatest diameter rather behind the centre. Within and a little below the margin of each valve a thin sloping ledge or plate projects inwards, and is most developed at the extremities (Fig. 10); surface smooth (finely polished in examples from Staneshiel Burn); shell thick; length $\frac{1}{30}$ inch.

We refer this species to *Bythocypris* doubtfully. The overlapping valve appears to be the left, but it is difficult to speak with decision on this point, both in this case as well as in some other Carboniferous species. Were the right valve the largest, then *Macrocypris* would apparently be the better genus in which to place it.

It is a comparatively common form among the Gayton Ostracods, occurring both as single and united valves. Individuals show some differences in relative length and height. Fig. 11 represents one of the longest of them, and rather suggests relationship with another Lower-Carboniferous species—*Argillœcia æqualis*, J. & K. MS. *Cythere? lunata*, J. & K. (undescribed), from the Carboniferous Limestone of Holwell, Somerset, has some resemblance to the present species, though larger; and it may probably be a related form.

4. Macrocypris Jonesiana, Kirkby. Plate VII. Fig. 12.

Bairdia Jonesiana (Kirkby), 1859. Ann. and Mag. Nat. Hist. ser. 3, vol. ii. p. 432, pl. xi. figs. 1, 2.

Fig. 12 represents a specimen that comes nearer to this species than anything else we know. The dorsal margin is not so regularly arched as in *B. sublunata*, the posterior slope being longer and flatter than the anterior; and the anterior extremity is broadly rounded, while the posterior is subacute. We refer it to *M. Jonesiana*, with some doubt.

5. Cytherella extuberata, Jones and Kirkby. Plate VII. Figs. 13*a*, 13*b*, 13*c*, 13*d*.

Leperditia Okeni (Münster), var. *extuberata*, J. & K. 1880, Quart. Journ. Geol. Soc. vol. xxxvi. p. 588.

This species was discovered by one of us several years ago in the Calciferous Sandstones of Fifeshire. It was then considered to belong to *Leperditia*, and to be probably a variety of the common Carboniferous species, *L. Okeni* (Münster). This opinion was arrived at by a study of specimens imbedded in the matrix, only partially showing external characters, and by our taking the straight edge as the uppermost or dorsal margin.

Some years after this we received examples of the same fossil from our friend, Mr. James Bennie, who collected them from the Calciferous-Sandstone shale, at Staneshiel Burn, already mentioned. These specimens were, in many cases, single valves, finely preserved, showing the interior; and from these it is evident, owing to one valve being much larger than the other, and from it having an internal marginal groove for the reception of the smaller valve, that

the species is more nearly related to *Cytherella* [1] than to *Leperditia*. To that genus then we refer it; and in doing so we consider that the convex edge is the back, thus bringing the large valve to the right hand, and the more compressed or narrowest half of the carapace to the front as the anterior portion, and so have it in harmony with what is to be observed in other *Cytherellæ*.

From the Gayton specimens we give the following provisional description, with the intention of noticing the species more fully on another occasion.

Carapace subovate in outline; dorsal margin arched and highest about the posterior third; ventral margin straight or faintly incurved; extremities rounded, the posterior obliquely so; the hinder third much higher than the anterior; the carapace is tumid and high behind, compressed and low in front. The left valve is much smaller than the right; not much more than half as high as long, while the right is two-thirds as high as long; the right valve overlaps the left round the whole of its margin. Viewed from above the profile of the carapace is subovate, widest behind, pointed in front. End view oval. It is rather thick-shelled; the surface is smooth. Length $\frac{1}{30}$ inch.

The only other English locality for this species is Skellygate, Northumberland, where it occurs in a shale of the Lower-Carboniferous Series.

6. Cytherella attenuata, Jones and Kirkby. Plate VII. Figs. 14*a*, 14*b*, 14*c*.

Leperditia attenuata, J. and K. 1880, Quart. Journ. Geol. Soc. vol. xxxvi. p. 588.

One or two examples of another form, also formerly referred by us to *Leperditia*, occur with the other specimens from Gayton. It is often found along with *C. extuberata* in Fife, and, like the latter, it probably belongs to *Cytherella*. Indeed, we are not sure that the relationship may not be closer to the species just described, for it is possible that the differences observed may be due to sex. These differences consist chiefly in the somewhat neater form of *attenuata*, in the less strong (though still complete) overlap of the right valve, and in the lateral contour, when seen from above, being more regularly lenticular, the ends being almost alike, and the greatest diameter being near the centre. In this latter character it certainly looks very different from *C. extuberata*, and for the present we leave it a distinct species.

There are thus six recognizable forms, or species, among the Ostracods from the Gayton Boring, namely—

Kirkbya variabilis, sp. nov.
K. plicata, J. and K.
Bythocypris sublunata, J. and K., MS.
Macrocypris Jonesiana (?), K.
Cytherella extuberata, J. and K.
C. attenuata, J. and K.

Five of these were previously known to us from other localities; and one, which is the most abundant, is new. Of the former, all of them are essentially Lower-Carboniferous forms, being most com-

[1] See Monogr. Carbonif. Entom. Pal. Soc. 1884, p. 58.

monly found in the Calciferous-Sandstone Series of Scotland, and the more or less equivalent Carboniferous Limestone of England. Three of them, indeed,—*B. sublunata*, *C. extuberata*, and *C. attenuata*,—have not occurred above the Calciferous Sandstones; and the other two do not range higher than the lower portion of the Carboniferous-Limestone Series of Scotland; that is, speaking of the Carboniferous rocks only, for it should not be forgotten that *M. Jonesiana* is a Permian species.

EXPLANATION OF PLATE VII.

(The specimens are magnified about 25 diameters.)

Fig. 1-3. *Kirkbya plicata*, J. and K.; 1*a*, left valve; 1*b*, view of ventral edge; fig. 2, right valve; fig. 3*a*, left valve, showing reticulated surface; 3*b*, end view.

Fig. 4-8. *K. variabilis*, sp. nov.; 4*a*, carapace, right valve outwards; 4*b*, ventral view; 4*c*, end view; fig. 5*a*, carapace, right valve outwards; 5*b*, ventral view; fig. 6, left valve; fig. 7*a*, carapace, left valve outwards; 7*b*, end view; 8*a*, carapace, left valve outwards; 8*b*, ventral view.

Fig. 9-11. *Bythocypris ? sublunata*, J. and K.; 9*a*, carapace, right valve outwards; 9*b*, ventral view; 9*c*, end view; fig. 10, interior of left valve; fig. 11, left valve.

Fig. 12. *Macrocypris Jonesiana ?* Kirkby; right valve.

Fig. 13. *Cytherella extuberata*, J. and K.; 13*a*, carapace, right valve outwards; 13*b*, left valve; 13*c*, dorsal view; 13*d*, end view; 13*e*, interior of right valve. Fig. 13*e* is from Staneshiel Burn, Roxburghshire.

Fig. 14. *C. attenuata*, J. and K.; 14*a*, carapace, left valve outwards; 14*b*, ventral view; 14*c*, end view.

III.—On the Palæontology of the Selachian Genus *Notidanus*, Cuvier.

By A. Smith Woodward, F.G.S.,
of the British Museum (Natural History).

(*Continued from page* 217.)

Of the upper dental series, Probst[1] attempts to give a tolerably complete account, but it is only illustrated by very imperfect woodcuts. Two of the foremost awl-shaped teeth are figured by Lawley (*l.c.* figs. 2, 3), and the same author ascribes to the upper jaw of this species three other of the Pliocene specimens. Fig. 19 represents an anterior upper tooth from the Middle Eocene of Hampshire, and the original of Fig. 20 is another from the Miocene of Baltringen, Würtemberg. The former (B. M., p. 4707) exhibits a short thick base with an oblique principal cone, in front of which are a number of minute denticulations; posteriorly there is only one secondary cone, pointing sharply backwards, and about half the size of the principal cone; and this is followed by another small denticle. The second specimen (B. M. 35533) has also a short thick root, and shows a somewhat similar crown; the large principal cone is followed by one small secondary and a terminal denticle, and in front there are

[1] In his first paper ("Ueber das Gebiss des *Notidanus primigenius*, Ag.," *l.c.*): in 1879 the author expressed doubts as to the accuracy of his previous work, but it is not improbable that all the specimens at first figured may belong to the species under consideration.

a few coarse serrations at its base. To a position somewhat further back in the upper jaw may also be referred the tooth represented in Fig. 21; this was obtained from the Red Crag of Woodbridge, and is preserved in the Reed Collection of the York Museum.

N. primigenius is perhaps the most widely distributed of all the extinct species of the genus, and is especially noteworthy on account of its considerable size. It is much larger than *N. serratissimus*, and its lower teeth also differ from that species in having more secondary cones, and in possessing finer anterior serrations, which are not regular, but decrease from above downwards. With the exception of a brief notice by myself,[1] there appears to have been no record hitherto of the occurrence of the species in Britain, but, as already stated, the originals of three of the figures illustrating this description have been obtained from English deposits, and are derived from the Middle Eocenes of Barton and Bracklesham, and the Red Crag of Suffolk. It is not known to occur in the London Clay.

On the Continent there are numerous allusions to teeth of this specific type, from the Oligocene and Miocene, and the British Museum also contains specimens from the Eocene of Klein Spauwen, in Belgium. A single tooth has likewise been described by Gibbes from the Eocene of Richmond, in Virginia, and shows that this species extended into the New World in early Tertiary times: it would be unsafe at present, however, to regard all the notices of *N. primigenius* as correct determinations, although the analogy of other fossil sharks is far from rendering improbable so wide a range in time and space as has already been assigned to it. Winkler mentions specimens from the Middle Oligocene of Belgium; Rouault and others record the species in France; Orueta in Spain; Adams in Malta; Lawley in Italy (Pliocene); and the references to German specimens are far too numerous to mention.

15. N. REPENS, Probst.

1879. *N. repens*, J. Probst, Württb. Jahresh. vol. xxxv. pp. 163-166, pl. iii. figs. 18-22.

Founded upon some small teeth from the Miocene of Baltringen, Würtemberg. The cones are all extremely low, and were perhaps eight in number in the lower teeth, with large anterior serrations: the specific identity of all the specimens figured appears somewhat doubtful.

16. N. BISERRATUS, Münster.

1842. *N. biserratus*, Graf von Münster, "Beitr. Petref." pt. v. p. 66, pl. xv. fig. 9.

This species was founded upon a small tooth from the Oligocene of Neudorft in the Vienna Basin, but does not appear to have been recorded since its original description. The principal cone is about four times the size of the largest of the secondary cones, and the latter are no less than twelve in number. The eight anterior cones are distinctly serrated on both edges.

[1] Smith Woodward, "Chapters on Fossil Sharks and Rays.—II.," Science Gossip, vol. xx. (1884), pp. 229, 230.

17. N. Loozi, Vincent.

1876. *N. Loozi*, G. Vincent, Ann. Soc. Malacol. Belgique, vol. xi. p. 126, pl. vi. fig. 5.

I am indebted to Mr. G. F. Harris for the reference to M. Vincent's description of a fragmentary tooth of *Notidanus* under the specific name of *N. Loozi*. The specimen in question was obtained from the Lower Landenien (Thanet Sand) of Belgium, and exhibits nothing beyond the anterior portion of the crown: it indicates a species about the size of *N. primigenius*, and it is distinguished from the tooth of this well-known form by the peculiar shape of the cones, and the very large denticulations in front. Notwithstanding its imperfect character, the type-specimen appears to justify the author's conclusions.

18. N. Targionii, Lawley.

1877. *N. Targionii*, R. Lawley, Atti Soc. Toscana Sci. Nat. p. 71, pl. ii. fig. 3.

A small species founded upon lower teeth from the Pliocene of Tuscany. The type specimens are evidently very similar to the mandibular teeth described above as immature examples of *N. serratissimus*.

19. N. gigas, Sismonda.

1857. *N. gigas*, E. Sismonda, Mem. R. Accad. Sci. Torino, ser. 2, vol. xix. p. 460, fig. 13.
1877. ,, ,, R. Lawley, Atti Soc. Toscana Sci. Nat. p. 68, pl. i. fig. 6.

A species allied to *N. primigenius*, but with the lower teeth relatively longer, the cones less regular, and the anterior serrations of the crown more pronounced. Occurs in the Miocene of Mondovi, Piedmont, and the Pliocene of Volterrano, Tuscany.

It is interesting to be able to add that teeth undoubtedly referable to this species have also been obtained from the Pliocene of Britain. Through the kindness of Mr. Reed, the Hon. Curator in Geology, and Mr. Noble, the Hon. Secretary, of the York Museum, I have had the opportunity of examining the beautiful series of Crag Notidanidæ in the Reed Collection of that institution, and among these there is a very perfect crown of *N. gigas*, shown in the accompanying woodcut (Fig. 1). The specimen has been considerably rolled

Fig. 1.—Tooth of *Notidanus gigas*, Sismonda. Red Crag, Suffolk. [Reed Coll., York Museum.]

and abraded, so that the anterior serrations are scarcely visible, and the root is wanting, but it is otherwise a most typical example. An upper side tooth in the same collection may also perhaps be associated with this form.

20. N. Meneghinii, Lawley.

1877. *N. Meneghinii*, R. Lawley, Atti Soc. Toscana Sci. Nat. p. 72, pl. ii. fig. 4.

Some large mandibular teeth from the Pliocene of Volterrano, Tuscany, have been described by Lawley under this specific name.

The principal cone is relatively large, and is followed by ten to twelve secondary cones; at its base the enamel of the crown extends far down upon the root, and the long anterior border thus produced is strongly serrated for quite two-thirds of its extent.

A tooth of this species from the Red Crag of Woodbridge is also

Fig. 2.—Tooth of *Notidanus Meneghinii*, Lawley. Red Crag, Suffolk. [Reed Coll., York Museum.]

preserved in the Reed Collection of the York Museum. It is shown of the natural size in the woodcut (Fig. 2). An anterior upper tooth from the Red Crag of Bawdsey is also perhaps referable to the same form.

21. N. D'Anconæ, Lawley.

1877. *N. D'Anconæ*, R. Lawley, *loc. cit.* p. 73, pl. iii. figs. 1, 2.

A small species. The teeth consist of four to six acute cones, the first or principal cone being very large compared with the others, and the anterior edge is serrated for a considerable length. It is a rare form in the Pliocene of Volterrano and Orciano Pisano, Tuscany; and Probst[1] also describes some teeth from the Miocene of Baltringen, Würtemberg, under the same specific name, but this is a very questionable determination.

22. N. problematicus, Lawley.

1877. *N. problematicus*, R. Lawley, *loc. cit.* p. 74, pl. iii. figs. 3, 4.

This is a very doubtful species founded upon an upper tooth from the Tuscan Pliocene, and merely named—as the author states—to call attention to the peculiar specimen figured.

23. N. anomale, Lawley.

1877. *N. anomale*, R. Lawley, *loc. cit.* p. 74, pl. iii. fig. 5.

If the mandibular tooth figured by Lawley as the type of this species is genuine—as seems probable, notwithstanding the fracture across its middle—it represents the largest member of the genus hitherto recorded. There are no less than 14 secondary cones, and the tooth measures more than five centimetres in total length. The principal cone and the three following are curiously contorted—though it is possible that this may be an abnormal condition—and the anterior edge of the first is strongly denticulated. An upper tooth is also figured (pl. iii. fig. 6) which may perhaps belong to the same form. Both are from the Pliocene of Tuscany.

[1] J. Probst "Beiträge zur Kenntniss der fossilen Fische aus der Molasse von Baltringen," Württb. Jahresh. vol. xxxv. (1879), pp. 166—169, pl. iii. figs. 6—11.

Such is a brief enumeration of the various specific types of fossil Notidanidæ that have hitherto come under my notice. One other form has also been assigned to this genus by Winkler,[1] under the name of *N. Orpiensis*, but this is apparently an erroneous determination: the type-specimens are from the Thanet Sand (Heersien) of Orp-le-Grand, Belgium, but only one (*l.c.* fig. 15) seems referable to *Notidanus*, and that is too imperfect to name specifically.

And now, in conclusion, there are one or two general considerations suggested by the foregoing facts to which it may be interesting briefly to refer. On examining the various forms of teeth in stratigraphical order, it is at once evident that there are distinct traces of specialization. In the earliest Jurassic types hitherto known, with a single exception (*N. serratus*), the secondary cones are only two, three, or four in number, while most members of the genus of Cretaceous and Tertiary age possess at least six or seven in the lower teeth, and one Pliocene species (*N. anomale*) has been recorded with no less than fourteen: it is also noteworthy that some of the Jurassic teeth are characterized by the absence of anterior serrations on the principal cone. Again, it is interesting to observe that the very deep compressed fibrous root of the more recent Notidanidæ only began to assume its peculiar characters towards later Cretaceous times, the base in such species as *N. serratus* and *N. Daviesii* being comparatively thick and depressed, and very suggestive of that of *Hybodus*. The earliest species of *Notidanus*, indeed, have teeth so remarkably similar to those of certain Hybodonts, that not only did Phillips—as already stated—figure two specimens under the name of *Hybodus polyprion*, but at least one other palæontologist[2] appears to have made the reverse mistake. A careful study of a large series of specimens of the well-known Stonesfield species results in the discovery of some teeth that may almost be regarded as links between the two. The originals of Figs. 1, 2, Pl. VI., for example, are such forms as would be commonly associated with *Hybodus polyprion*, but a very slight modification is necessary to convert them into most typical Notidanidæ, and I have considerable doubts as to the propriety of placing them with *Hybodus* at all. To transform a long-coned Hybodont tooth into one of *Notidanus*, it is only necessary to assume lateral compression and the reduction or loss of the anterior secondary cones, and the teeth represented in Figs. 1 and 2, Pl. VI., exhibit a marked approach to this condition. Fig. 1 shows a large, compressed principal cone, preceded by four secondary cones, and followed by two others, the former being reduced to quite small denticles, while the latter are comparatively well developed: the front edge of the principal cone is distinctly denticulated for half its length, and so also is the first secondary; and there are traces of vertical wrinkles

[1] T. C. Winkler, "Mémoire sur quelques Restes de Poissons du Système Heersien," Archiv. Mus. Teyler, vol. iv. fasc. i. pp. 12, 13, figs. 13–17.

[2] E. Favre, "Description des Fossiles du Terrain Oxfordien des Alpes Tribourgeoises," Mém. Soc. Paléont. Suisse, vol. iii. (1876), p. 16, pl. ii. fig. 1. The tooth is described as *Notidanus* sp., but the figure agrees much more closely with that of a species of *Hybodus*.

at the base of the crown. Fig. 2 is a smaller but very similar tooth, and the characters of both these specimens are such that they might well be looked upon as closely allied to ancestral Notidanidæ, even if not actually upon the main line of descent of this family.

Another interesting fact worthy of consideration is the distinct evidence of wear already noted in the dentition of the *N. eximius* of Schnaitheim (p. 210); it is impossible to conceive of this taking place in Sharks that have the teeth so loosely attached to the jaw, and so frequently replaced as are those of the living Notidanidæ, Lamnidæ, Carchariidæ, etc., and I have never observed the peculiarity either in the Recent, Tertiary, or Cretaceous forms. The circumstance is very suggestive, indeed, of the oldest Notidanidæ having the teeth as firmly implanted as those of the Hybodonts, in which there were two or more rows in function at a time, and in which also the longest cones often show most evident traces of abrasion. The shape of the root is quite in accordance with this supposition. It is proper to add, however, that I have met with no very decided abrasion among the large series of British Museum specimens of *H. polyprion*, which seem most nearly to approach *Notidanus*, although this fact may be partly accounted for by the considerable rolling to which many of the teeth have been subjected before entombment in the Stonesfield Slate; the cones of the Carboniferous *Cladodus* are often much worn down, and so likewise are those of the long-coned species of *Hybodus* in the Muschelkalk.

As to the precise significance of these various points of similarity between the Hybodonts and the primitive Notidanidæ, it would be unsafe at present to express any definite opinion. Except in the structure of the skull, which is very similar,[1] the latest members of each family exhibit many important differences. The Hybodonts have two (spinous) dorsal fins, and at least since Jurassic times the Notidanidæ have possessed only one; in the last of the Hybodonts, moreover, there are well-calcified vertebræ, while so advanced a stage is far from reached in the living Notidanidæ. I have likewise been able to determine that the Wealden species of *Hybodus* only possessed five branchial arches; and there are also other points of divergence to be taken into account. When, however, more is known of the anatomy of the earliest Mesozoic forms, it may still be possible to show that the evidence of the teeth is not altogether misleading, but that even if the Notidanidæ are not an early offshoot of the Hybodontidæ, they are at least derived from the same primitive stock.

EXPLANATION OF PLATE VI.

Fig. 1. Tooth commonly referred to *Hybodus polyprion*, Ag. Great Oolite, Bath. B.M. (p. 2186.)

„ 2. Tooth commonly referred to *Hybodus polyprion*, Ag. Great Oolite, Stonesfield. B.M. (35494.)

„ 3. *Notidanus eximius*, Wagn.; lower tooth. Corallian, Schnaitheim. B.M. (35763.)

[1] Smith Woodward, "On the Relations of the Mandibular and Hyoid Arches in a Cretaceous Shark (*Hybodus dubrisiensis*, Mackie)," read before the Zoological Society, April 20th, 1886.

FIG. 4. *Notidanus eximius*, Wagn.; lower tooth, outer view. Corallian, Schnaitheim. B.M. (35763 *a*.)
„ 5. *Notidanus eximius*, Wagn.; upper tooth, inner view. Corallian, Schnaitheim. B.M. (22500.)
„ 6. *Notidanus sp.*; upper tooth, outer view. Corallian, Schnaitheim. B.M. (22502.)
„ 7. *N. serratus*? Fraas; upper tooth, outer view. Oxfordian, Scarborough. B.M. (35667.)
„ 8. *N. Daviesii*, A. S. Woodw.; lower tooth, outer view. Oxfordian, St. Clement's. Oxford Museum.
„ 9. *Notidanus sp.* Oxfordian, St. Clement's. Oxford Museum.
„ 10. *N. microdon*, Agass.; anterior upper tooth, outer view. Chalk, Norwich. B.M. (24927.)
„ 11. *N. microdon*, Agass.; upper tooth, outer view. Chalk, Sussex. B.M. (4164.)
„ 12. „ „ „ „ „ „ Kent. B.M. (44580.)
„ 13. „ „ lower „ ? inner „ „ Norwich. B.M. (24928.)
„ 14. „ „ „ „ outer „ „ „ B.M. (35648.)
„ 15. „ „ „ „ „ „ „ „ B.M. (48950.)
„ 16. *N. lanceolatus*, A. S. Woodw.; upper tooth, inner view. Gault. B.M. (P. 1227.)
„ 17. *N. dentatus*, A. S. Woodw.; upper tooth, outer view. L. Greensand, Amuri Bluff, New Zealand. B.M. (P. 2303.)
„ 18. *N. dentatus*, A. S. Woodw.; lower tooth. outer view. L. Greensand, Amuri Bluff, New Zealand. B.M. (P. 2303 *a*.)
„ 19. *N. primigenius*, Agass.; anterior upper tooth, inner view. M. Eocene, Hampshire. B.M. (P. 4707.)
„ 20. *N. primigenius*, Agass.; anterior upper tooth, outer view. Miocene, Baltringen. B.M. (35533.)
„ 21. *N. primigenius*, Agass.; anterior upper tooth, outer view. Red Crag, Woodbridge. Reed Collection, York Museum.
„ 22. *N. primigenius*, Agass.; lower tooth, outer view. M. Eocene, Barton Cliff. B.M. (P. 1224.)
„ 23. *N. serratissimus*, Agass.; tooth, outer view. London Clay, Sheppey. B.M. (24618.)
„ 24. *N. serratissimus*, Agass.; young tooth, outer view. London Clay, Sheppey. B.M. (28890.)
„ 25. *N. serratissimus*, Agass.; lower tooth, young. inner view. London Clay, Sheppey. B.M. (30550.)
„ 26. *N. serratissimus*, Agass.; lower tooth, young, inner view. London Clay, Highgate. B.M. (43133.)

[B.M. = British Museum. All the figures are of the natural size.]

IV.—On the District of the Ancient Glaciers of the Isar and of the Linth.

By Prof. Albert Heim, of Zurich, and Prof. Albrecht Penck, of Vienna.[1]

In order to interchange our views, and arrive at a common understanding on the question of the connection of glaciers with the formation of lakes, we undertook a joint excursion in Upper Bavaria, in the district of the Ammer Lake, Wuerm Lake, Staffel Lake, and Rieg Lake, and later, in the month of September, we visited together the shores of the Lake of Zurich, partly accompanied by Dr. K. I. V. Steenstrup, of Copenhagen, Dr. A. Wettstein and Dr. E. Brueckner, of Hamburg. We have drawn up a short protocol, both on the facts observed and of our views respecting them, which we here propose to communicate.

[1] Translated from the authors' MSS., by Dr. G. J. Hinde, F.G.S.

I.—*The Division of the Quaternary Formation in the District of the Highland Lakes of Bavaria.*

Throughout the lake district of Upper Bavaria, the basement bed is everywhere formed by the "Flinz" (Upper Miocene Clay, Marl, and Clayey Sandstone), on which rest the Quaternary beds, which are briefly characterized below.

(*a*.) A layer of Conglomerate (Nagelfluh) from 20 to 30 mètres in thickness, having a nearly even surface, and rising with remarkable uniformity in a gentle slope towards the S. and S.W. It consists of pebbles of limestone and dolomite, and contains very few erratics of Archæan rocks. The material is fairly evenly rounded, and united by a calcareous cement. Hollow boulders and decayed pebbles are abundant in it.

(*b*.) A deposit of gravel which may readily be distinguished from the Conglomerate (*a*) or "Deckenschotter," by the greater irregularity in the size of the pebbles, and the far greater abundance of pebbles of Archæan rocks. It is seldom cemented into a conglomerate, it contains no hollow boulders, but there are in it rolled fragments of the diluvial Nagelfluh mentioned above (*a*). This gravel deposit is the Lower "Glacialschotter" of Penck (Die Vergletscherung, etc., p. 142). It is also of great uniformity and is widely distributed. Its general dip from south towards the north is less than that of the diluvial Nagelfluh (*a*), so that in the lake district to the south it is deposited lower on the slopes of the valleys (which consist of Miocene Flinz) than the Nagelfluh (near Weilheim 100 m.), whilst towards the north, near Munich, it overlies the Nagelfluh.

Here, in the Isar Valley above Grosshesselohe, an intermediate, independent deposit of gravel (intermediate Schotter, Penck, Die Vergletscherung, p. 290) is interposed between the Nagelfluh and the Lower Glacialschotter, which has not yet been noticed in the lake district.

(*c*.) An irregular covering of genuine morainic material, swelling up in places into hilly ridges, extends in the lake district, in a very discordant manner, as well over the elevations occupied by the Nagelfluh, as over the Miocene Flinz, and the slopes of the diluvial gravels (*b*), up to the foot of the hills. Only in the district of the outer moraines (near Fürstenfeld-Bruck, etc.), are the diluvial gravels (*b*) and the slopes of Flinz free from this morainic covering.

The moraines show nearly the same admixture of pebbles as the gravels (*b*). They contain scratched boulders, together with angular fragments of the same kinds of rock. All these scratched and angular fragments are usually small, they very seldom reach a diameter of half a mètre, generally they vary from the size of a nut to that of one's fist. This type which is characteristic of the ground-moraine is particularly represented also by the longitudinal ridges. Therefore the latter may be recognized as the ground-moraine scooped out at the margin of the ancient glacier.

In the district embraced in our excursion, no moraines are present at the base of the Nagelfluh or below the glacial gravels (*b*). Below these latter, however, beyond the excursion district, near

Toelz, Laufen on the Salzach, and at Stefansbrücke near Innsbruck, Penck has discovered moraines; but at the base of the Nagelfluh, Tertiary strata exclusively have been met with.

Where we met with recently exposed surfaces, showing the deposition of the moraine on the diluvial Nagelfluh (at Tutzing, Berg, Starnberg), the surface of this latter was smoothed and polished as distinctly as if it had been a homogeneous rock, and striated in the same direction as the course of the valley. The individual pebbles in the Nagelfluh were also evenly cut through in section.

Also when the contact surface of the moraine and the glacial gravels (*b*) was exposed, there was nearly always a sharply-marked, often discordant, boundary between the two deposits, without disturbance in the underlying gravel; and occasionally the projecting boulders in the gravel were striated in the direction of the valley, though no connected striated surface had been formed on them.

North of the Starnberg Lake, we noticed a moraine irregularly interpenetrated with beds of gravel and sand; which we recognize as a deposit formed near the terminal end of a glacier (Penck, Vergletscherung, etc. p. 132, figs. 4, 5).

II.—*The Quaternary Deposits in the District of the Lake of Zurich.*

In the valley of the Lake of Zurich, as in the lake district of Upper Bavaria, Upper Miocene strata form the foundation on which the Quaternary deposits rest, and these latter are also divided into gravels (Schotter) and moraines.

In contrast, however, to the exceptional regularity with which the gravel deposits in the Bavarian lake district succeed each other under the moraines, those at the lower end of the Lake of Zurich show, on the one hand, an extremely slight connected development, and on the other, they present such great differences in regard to the respective elevations at which they are deposited, that it seems almost impossible definitely to mark out their limits, or to parallel the deposits of different localities.

(*a.*) There is indeed found occasionally, on certain particular elevations between the valleys, a deposit of Nagelfluh, resembling petrographically the Bavarian diluvial Nagelfluh (Uetliberg 870 m., Baden 470—490 m., Sihlsprung near Hirzel [outside the bounds of our united excursion] 580—640 m.); but this is so limited in its distribution, and the places in which it appears are so far apart, that, with our present knowledge, it cannot be considered as the remains of a general covering. Besides, moraines occur under the cavernous Nagelfluh of the Uetliberg, whilst they have never been met with below the Bavarian diluvial Nagelfluh, and on the other hand moraines do not any longer appear above this Nagelfluh as they do in that of Bavaria. The cavernous Nagelfluh of Sihlsprung near Hirzel rests, according to Heim, on ground-moraines, and is covered by immense upper moraine deposits.

(*b.*) A somewhat different formation of loose gravels (Schotter) and Nagelfluh, either with or without decayed pebbles, is present, though in very few localities, on the slopes of the valley of the Lake

of Zurich (Waedensweil, Utznach). We find similar gravels and Nagelfluh far wider distributed at the north-east border of the Glatt Valley, where they lie between the ground-moraine and the upper-moraine. Near Dürnten and Wetzikon, lignites are deposited between the gravel and the ground-moraine. These deposits of rolled materials also, which we here place under (*b*), are isolated to such an extent, and deposited at such different heights, that they cannot be regarded, at least so far as the valley of the Lake of Zurich is concerned, as the remains of an extended connected valley deposit.

(*c.*) The Nagelfluh of the Au peninsula, on the Lake of Zurich, is distinguished by its "delta structure" from the above-mentioned deposits of rolled materials in the neighbourhood of the Lake, and it has no equivalent in our Bavarian excursion-district. It calls to mind the ancient Kander delta, on the Lake of Thun, and according to Penck (Vergletscherung, etc., p. 343), the Nagelfluh of Biber in the Inn valley, and that of the Mönchsberg of Salzburg. Its relation to the moraines is not exposed. From the mode of its occurrence it very probably belongs to the base of the upper moraine.

(*d.*) Of all the Quaternary deposits, the moraines of the Lake of Zurich play the most important part. There is an astonishing contrast between them and the typical Bavarian moraines. The morainic hills are shown by the prevalence of large, angular, erratic blocks and sand, and the diminished quantity of clayey material, to belong mostly to the upper-moraines; such are altogether absent in the Bavarian lake district. The pure ground-moraines form in Switzerland an irregular, but not very thick layer, overlaid by the upper-moraines, or by the gravelly deposits above mentioned. Only the terminal moraines, and not the longitudinal moraines, have obtained a great part of their materials from the ground-moraines.

III.—*The Relation of the Upper Bavarian Lakes to the Quaternary Deposits.*

The Ammer Lake and Wuerm Lake occur in wide valleys, which form deep bay-shaped indentations in the southern margin of the same deposit of Nagelfluh. In the valleys especially, which have been excavated in the deposit of Nagelfluh, and also in the surrounding district of the above-named lakes, the gravels (I. *b*) are developed, and, indeed, they can be seen with constant characters, in the lower part of both lakes, in the upper part of Ammer Lake, and on the east margin of Wuerm Lake. The Lakes of Staffel and Rieg are situated to the south of the Nagelfluh district, where they extend themselves in a basin in the ancient Molasse, which is partly filled with the gravels I. *b.* (Schotter). They are bounded above and below by ridges of the dislocated Molasse, whilst between both only horizontal beds of the gravels (I. *b*) are raised above the surface.

The moraines form a surface layer, alike on the tops of the hills between the lakes, as on their slopes down to the margins of the lakes, thus, as a rule, covering discordantly the outcrops of Nagelfluh, Miocene Flinz and gravel (I. *b*); so that these various deposits are only exposed in lateral gullys or in steep cliffs.

Ammer Lake and Wuerm Lake are limited above and below by recent deposits. Their valley basins are bounded below by moraine walls, which the outflow from the lake cuts through, forming extremely narrow valleys. In the sections laid bare, the gravel (*b*) is shown under the moraine, and in the Wuerm Valley the Flinz is also exposed. Lower down the valley, beyond the moraine walls bounding the lake-basins, the gravel (I. *b*) forms extended terraces, partly interrupting the covering of the Nagelfluh and the outer moraine.

IV.—*The Relation of the Lake of Zurich to the Quaternary Deposits.*

Wuerm Lake and Ammer Lake, both in their relation to the Quaternary deposits, and also to the Molasse valley to which they belong, show very different phenomena to those of the Lake of Zurich and of the other large lakes of the Alpine borderland of Switzerland. The valleys in the Molasse in these latter are much deeper. A deposit like the gravel (Schotter) (I. *b*) in Bavaria, which both above and below the lakes exhibits the same uniform slope, is altogether unknown in the Lake of Zurich, in which the only gravels found are those mentioned under (II. *b*). On the declivities of the valley of the Lake of Zurich, the Molasse rock is itself carved into distinct erosion terraces, independent of the stratification, and these are often only sparsely covered with glacial *débris*, and not seldom altogether bare, whilst a similar condition of things is not observable on the borders of Wuerm Lake and Ammer Lake on account of the slight elevation of the outcrop of the Flinz and of the valley slopes, and of the soft character of the material. In Switzerland, for the most part, the valleys below the lake basins remain widely open, and show more especially the characters of main lines of ancient valleys. Hardly anywhere is the outlet of a lake through a narrow gully. The Molasse in the district of the Lake of Zurich is plainly not horizontal, but it forms a shallow trough between the Alps and Jura: the depression in this has affected the ancient erosion-terraces in unequal proportions.

The Quaternary deposits rest on the dislocated Molasse terraces of the declivities of the valley, so that the lateral moraines, with their somewhat steeper inclinations in the direction of the valleys, cut the margins of the Molasse terraces at an oblique angle.

On the other hand, Rieg Lake and Staffel Lake in some measure call to mind certain of the smaller lakes of the Alpine borderland, as, for example, Greifen Lake and Pfaeffikon Lake in the Glatt district.

V.—*The Question of the Origin of the Lake-Basins.*

In our excursion in Upper Bavaria, Heim had the opportunity of ascertaining the facts respecting this district published by Penck in his "Vergletscherung der deutschen Alpen."[1] On the other

[1] A review of this work is in the GEOLOGICAL MAGAZINE for 1883, Decade II. Vol. X. p. 177.

hand, Penck was able to confirm the facts which had been published by A. Wettstein in his work, "Geologie von Zürich und Umgebung." We are completely agreed respecting the facts observed, and differences can only arise on the conclusions to be drawn from the facts. The great differences in the Quaternary deposits of Bavaria and of Switzerland deserve special prominence. They teach that the greatest prudence is necessary, in regard to generalizations based on conclusions drawn from a limited area.

The grounds which Penck brings forward in favour of the Glacial origin of the Bavarian highland lakes are :—(1) the coincidence of the position of the lakes with the glacial deposits; (2) the characters of the lake valleys are such as are produced by erosion; and (3) the age of the lakes.

Their character as products of erosion is made clear from the fact that they are valley-shaped gaps in a continuous uniform series of undisturbed stratified gravels, whilst their diluvial age is proved by the fact that these stratified gravels end with the deposit of the diluvial Nagelfluh (I. *a*). On the other hand, both above and below the lakes, as well as round their margins, the horizontally stratified gravels (Schotter) (I. *b*) are shown, in which the lake-basins appear to form excavations. As these gravels (I. *b*) are, on the one hand, covered by moraines, and on the other, contain a notable number of pebbles of Archæan rocks, which could only have been transported by glaciers from the central region of the Alps over the passes of the limestone Alps, they must therefore have been formed immediately before the advance of the glacier into the lake district. As, however, the lake-basins are excavated in these gravels, they are necessarily more recent; they could thus not have yet been in existence at the commencement of the last glaciation of this district to which the gravels correspond. On the other hand, the deposition of the moraines on the slopes of the lake-basins shows that these latter were formed at the time of the retreat of the glacier. Their origin must therefore have taken place at the time of the glaciation itself.

Of these three grounds brought forward by Penck, the first one is established. As regards the second, it might be said that the gaps in the south margin of the covering of Nagelfluh might have been produced in it originally; that glacial-tongues, which covered the areas of the lake-basins, produced the Nagelfluh, as a fluvio-glacial deposit, whilst they protected the lake-basins against the accumulation of gravels. Against this, is,

(*a*.) The high degree of uniformity in the petrographical characters and the stratigraphical deposition of the Nagelfluh (I. *a*).

(*β*.) The absence of any morainic material below the Nagelfluh, as also the non-existence of genuine glacial materials, such as striated boulders, etc., within it.

A further possible mode of formation of the lakes might consist in a relatively small change of level in the lake district, by which the original slope of the Nagelfluh was diminished, whilst the valleys cut in it became reversed, and converted into lake-basins. This is

the more conceivable, since the southern part of the covering of Nagelfluh has a somewhat steeper dip than the more northern part; this, however, may readily be regarded as its original structure.

A positive proof of such changes cannot be found in the oldest deposits of the district of the Bavarian highland lakes, which thus contrast with those of the Lake of Zurich, because connected erosion-terraces are wanting, and more especially because the position of the strata of the Miocene Flinz cannot be accurately determined. But though the possibility of such an origin of the lakes through local changes of level cannot be proved to be inconceivable, it is so, nevertheless, if it leaves the coincidence of the extension of the glacier with the formation of the lakes, and the absence of lakes beyond the margin of the glacier, to be explained as the result of pure chance.

As regards the third ground for the glacial origin of the Bavarian highland lakes, *the age of the lake-basins*, it may be remarked that the gravels (I. *b*) are deposited on the slopes of Nagelfluh and Flinz. As the gravels were formed before the advance of the glacier, the valley which they cover, as well as the gaps in the covering of Nagelfluh, must also have been in existence *before* the glacier, as, moreover, Penck has already noticed (Vergletscherung, p. 357). There remains, therefore, no further solid excavating work for the glacier to perform, but merely the re-excavation of a part of the old valley out of the gravels (I. *b*), leaving behind many fragments of the same on the slopes, and further, the scooping out of the hollow, 120 m. in depth, in the soft Flinz. It may be noticed that the Flinz is a marly-clay which falls to pieces in water, and although rock in appearance, it would offer less resistance to the course of the glacier, than even loose pebbles.

Staffel Lake and Rieg Lake lie between ridges of Molasse, parallel to the Alps. The oblique partition separating them is formed of huge masses of the gravels (I. *b*), which can hardly have been originally deposited in their present limits. Heim acknowledges, in view of this, that a re-excavation of a part of the gravels in the same northerly direction in which the Alpine valleys become open, is by far the most probable mode of the formation of these lakes. Heim also accepts a similar origin for the now extinct lake of Murnau and the lake Kochel. As, however, regarding these lakes, it is only a question of the re-excavation of basins of dislocation, in which the harder ridges of Molasse on their margins and the islands of the same have *not* been destroyed, we are both entirely of the same opinion respecting them.

On a consideration of the Bavarian highland lakes, Heim conceives the re-excavation of valleys filled with loose gravels, as also the scooping out of depressions in very yielding materials, and thereby the formation of lake-basins through glaciers, possible, as heretofore (comp. "Gletscherkunde," p. 382 at top, and p. 386), and in the present instances, as very probable. On the contrary, proofs of the formation of extended basins in hard rock and of the excavation of the same through glaciers cannot be found in this district.

Of the three grounds, which, according to Penck, support the glacial origin of the Lakes of Ammer, Wuerm, Rieg, and Staffel, only the two former are applicable to the Lake of Zurich, and the other large lakes of the Swiss Alpine borderland. But just as little as in the first case, the position of the lakes in the area of glacial deposits, and, in the second, the character of the lake valleys as produced by erosion, can be disputed, even so little can the age of the lakes be brought forward as a proof of their origin.

Whilst namely, on the one hand, the gravel deposits indicated by II. *a* and II. *b* are only thus locally and sporadically developed, so that no conclusion can be at present arrived at as to their former connection, it can neither be proved that the lake valleys are depressions in a former covering of diluvial Nagelfluh, nor that the lake-basins represent hollows in a gravel formation corresponding to I. *b*. There is thus nothing to add to our information respecting their Quaternary, *i.e.* Glacial age. But, on the other hand, the Nagelfluh of the Au represents a probably very ancient deposit, which, by its delta structure, proves the existence of the Lake of Zurich already previous to the commencement of the last glaciation, so that the lake cannot be attributed to its action. At the same time, the position of the rock-terraces of the declivities of the valley afford decisive proof of dislocations which affected the lake valley and produced the basin-shaped depression in it. Penck holds with Heim and Wettstein that there is undeniable evidence of the influence of dislocations in the formation of the basin of the Lake of Zurich, but he is nevertheless of the opinion, that with a more thorough investigation of the Swiss Quaternary gravel deposits, it may perhaps be found possible to discover a parallel between the deposits named I. *b* and II. *b* in the two areas respectively, and he holds the view that the lake-basin originally produced by dislocation may be to a greater or lesser degree excavated by glacier action. Heim also does not question the fact of a certain, though relatively small, amount of the scooping out of the lake-basin being due to the glacier.

Penck holds that to re-excavation may very probably be attributed the formation of the lakes of the Glatt valley, of the Greifen Lake and Pfaffikon Lake, in the same way as in the case of Rieg Lake and Staffel Lake, whilst Heim is disposed rather to explain the origin of these two lakes of the district of the Glatt valley to the blocking-up action of moraines.

There is, therefore, no real difference of opinion between us touching the Lake of Zurich and the Lakes of the Bavarian highlands, either as regards the facts or the conclusions from them; and as in the present case, so also does it often happen, that by a more exact conjoint examination, differences become of much less importance than they appear to be from a distance.

V.—Notes on some Rocks from Arabia Petræa.

By F. W. Rudler, F.G.S.,
of the Museum of Practical Geology.

Professor Hull, soon after his return from Palestine, was good enough to place in my hands, for microscopic examination, a collection of twenty sections of rocks prepared from specimens obtained in the course of his expedition. Subsequently I had the advantage of receiving thirteen small specimens of the rocks from which some of the sections had been cut; and respecting these rocks some lithological notes have been published as an appendix to Prof. Hull's Memoir.[1] At a later date I received seven other rock-specimens, representing the remaining sections in my charge; but for want of time these were laid aside unexamined until it was too late to refer to them in the published work. The object of the present notes is therefore to offer brief descriptions of these remaining rocks. At the same time I gladly seize this opportunity of correcting some errors which unfortunately crept into the previous descriptions.

I. *Pale Pink Granite, from a Dyke Penetrating Grey Granite, at Jebel Watiyeh.*

A fine-grained granitic rock, consisting mainly of opaque white felspar and hyaline grey quartz, speckled with a few dark green patches of an altered mica. It presents a general pinkish grey colour, due to a small quantity of ferric oxide disseminated through the rock, and specially marked on the weathered joint-surfaces of the specimen. The felspar is for the most part very turbid, even in thin sections. Many of the crystals exhibit a zonal structure, which is well defined by the arrangement of the included granular matter. Some of the felspar appears to be orthoclase, in an altered condition, and probably microcline is also present; but most of the felspar is a plagioclase, with extinction angles, in relation to the line of twin-composition, varying from 3° to 14°. In a good deal of the felspar, however, the edges of the hemitropic lamellæ are too blurred to allow the exact angles to be taken. Some of the felspar crystals measure in section as much as 3 mm. × 1·5 mm. The quartz is xenomorphous, occurring in the form of clear subangular grains, ranging from 0·5 to 1 mm. in diameter, and traversed by reticulating lines of pores. Much of it shows a polysynthetic structure in polarized light. A few folia of muscovite, or other white mica with straight extinctions, are distributed through the rock. This mineral may be a secondary product. But the dominant micaceous mineral is a biotite, or dark dichroic mica, occurring in aggregated laminæ, and mostly altered, after the habit of the ferro-magnesian micas, to a chloritic mineral. A few acicular crystals of apatite are present, penetrating alike the felspar and the quartz. Some grains of epidote may be detected; and magnetite is present in small quantity, while scattered through the rock are small patches of hematite and limonite, with here and there a few folia of chlorite.

[1] "Memoir on the Physical Geology and Geography of Arabia Petræa, Palestine, and adjoining Districts," Palestine Exploration Committee (1886).

II. *Red Granitoid Rock, with Micropegmatitic Structure, from Jebel Watiyeh.*

This rock is an intimate aggregate of flesh-red felspar and quartz, with grains of vitreous quartz and crystals of felspar scattered through the ground-mass. It may be regarded as a fine-grained binary granite, almost a microgranite, with porphyritic quartz and felspar; thus suggesting a transition to a coarse kind of quartz-felsite with a ground-mass of phanero-crystalline texture. The felspar is highly charged with reddish-brown granules, perhaps kaolin with limonite, which by their comparative opacity render the section very nebulous. The felspar is presumably a red orthoclase, and is associated with large crystalline grains of clear quartz with numerous pores. In places the felspar and quartz of the ground-mass are so intimately united as to form a beautiful micropegmatite or granophyre. The association naturally suggests contemporaneous, and probably rapid, solidification of the two minerals. In some cases the formation of the micropegmatite has started from a pre-existing crystal of felspar, whence the interblended felspar and quartz diverge in plumose forms. This is the rock referred to by Prof. A. Geikie in his "Text-book of Geology," second edition, 1885, p. 635, footnote 3.

The rock from Jebel Musa, No. 1, in the Appendix to the Memoir, described as a gneiss, seems rather to be a fine-grained granitoid rock. The faint tendency to foliation, suggested by a small specimen, is illusory. The rock, though diverging greatly from the normal granitic type, and presenting rather a granulitic texture, may probably be best described as a hornblende-granite.

III. *Red Porphyrite from Jebel Musa.*

This rock presents a compact base of deep tile-red colour, with subconchoidal fracture, in which are disseminated porphyritic crystals of red felspar and irregular dark green patches of an altered mineral, apparently a mica. Some of the large felspars reach a size of 4 mm. × 1·5 mm. Even in thin section they present a strong reddish colour, which is deepest around the inner border of each crystal, where the granules of ferric oxide are accumulated. Some of the crystals seem to be orthoclase, but others show indistinct polysynthetic twinning, with broad lamellation. Zonal structure is presented by some of the crystals. The other porphyritic constituents are green crystals, measuring about 1·25 mm. × 1 mm. These seem to be pseudomorphs after biotite; at least such an origin is suggested by their strongly-marked striæ, which seem to represent the basal cleavage of a mica, by the occasional curvature of the laminæ, and by the hexagonal form of some of the sections. This green epigenetic mineral is strongly dichroic, and is flecked with an opaque oxide of iron, probably magnetite. The slide also carries some irregular patches of chlorite. Apatite is present in rather stout six-sided prisms, both in the felspars and in the altered mica. Epidote occurs in aggregates of greenish-yellow grains, inclosed in both the porphyritic minerals. Quartz may be detected in interstitial spaces, but is apparently of

secondary origin. Probably the history of the rock has been somewhat of the following character:—The apatite, the biotite, the large felspars and the ground-mass successively solidified in the order here enumerated; the mica was afterwards transformed into a chloritic mineral, with separation of magnetite, while further alteration of the chlorite resulted in the formation of epidote, which may also have partly resulted from the decomposition of the felspar, inasmuch as it occurs in the heart of some of the larger felspar crystals.

IV. *Felsitic Tuff from Es Shomrah.*

This rock appears macroscopically to be a porphyritic felsite, with compact chocolate-coloured base and disseminated crystals of white felspar. Under the microscope, however, it is seen to contain angular fragments of various rocks, with broken crystals of plagioclase, forming a brecciated mass. Mr. F. Rutley, F.G.S., to whom I am indebted for having examined some of my sections, points out the general similarity of the ground-mass to that of the rhyolitic rock from Pont-y-Gromlech, which he described some years ago; but at the same time inclines to the view that in the present case the ground-mass consists of fine dust, in great part felspathic, perhaps associated with shreds of devitrified lava. Among the imbedded fragments, which vary in diameter from about 0·03 mm. to 2 mm., are rhyolites, or devitrified rocks showing banded and fluxion structure. Some of the fragments and imperfect crystals of felspar reach a size of 2·25 × 1·3 mm., and though mealy in texture, show traces of repeated twinning.

V. *Hornblende-augite Rock from Es Safeh.*

A coarsely crystalline, almost black rock, weathering with a rusty surface. Thin sections show large porphyritic crystals of brownish-green hornblende, colourless augite, and decomposed felspar, imbedded in a pale brownish ground-mass of felspathic microlites, with green products of decomposition. Some of the crystals of hornblende measure, in section, as much as 3 mm. × 1·2 mm. Most of them are much fissured and carious, inclosing green alteration-products, and having rather indistinct outlines, bordered by dark greenish granules. The best-defined sections are those cut approximately normal to the perpendicular axis. These show the common six-sided forms, bounded by the edges of {110} {010}, with intersecting lines of prismatic cleavage breaking up the section into characteristic rhombs. Elongated sections parallel to the vertical axis give longitudinal cleavage lines, and the extinction-angles in relation to these lines vary from 0° in some of the sections which are cut parallel to {100}, to a maximum of about 15°. The pleochroism is not very marked: $\mathfrak{a}$ = pale yellowish brown, $\mathfrak{b}$ = pale bottle green, $\mathfrak{c}$ = olive green. Much of the hornblende is twinned.

The augite appears in very sharply-defined crystals, which in thin sections are quite clear and colourless. Most of the sections are eight-sided, being limited by edges of {110} {100} {010}. Some of these measure nearly 1 mm. in the edge. The prismatic planes

dominate in some of the sections, and the pinacoids in others. The characteristic cleavage parallel to {110} is well displayed. Some sections of rhombic shape, cut approximately in the plane of symmetry (010), give extinction angles of nearly 40°.

Two sets of felspars may be noted. Those of the first consolidation occur in groups of large crystals, some of which give sections reaching a size of 2 mm. × 0·6 mm., three or four such crystals forming a cluster. All the felspar is profoundly altered. By reflected light it presents a dead white colour, but by transmitted light a reddish tint. Notwithstanding its advanced state of decomposition, the repeated twinning of a plagioclase may be detected, and the wide extinction angles of the broad lamellæ suggest a felspar of high basicity. The small felspars of later consolidation occur in crowds of slender interlacing crystals, with irregularly-terminated lath-shaped sections, measuring on an average 0·16 × 0·04 mm. The meshes of this reticulating mass of microlites are occupied by a green decomposition product, of fibrous and tufted structure, with strong depolarizing action between crossed Nicols. There are also large irregular patches of a green mineral, chloritic or serpentinous, following irregular cracks in the rock, and associated with calcite and epidote. The calcite also forms large crystalline masses and ill-defined patches, with aggregate polarization. Olivine appears to be represented by crystals which have suffered much alteration, and are mostly converted into green pseudomorphs with a brown margin. Magnetite is disseminated through the rock, and red and brown oxides of iron occur in patches.

It does not appear easy to bestow upon this rock an appropriate name. It is very similar to the rock No. 13, from Jebel esh Shomreh, described in the Appendix to the Memoir as a hornblende-augite andesite, but I am anxious to withdraw that name, as the rock is decidedly basic. Notwithstanding the large proportion of hornblende, the affinities of the rock appear to lie rather with the dolerites and diabases. Its structure is in no way related to that of the diorites. With a little more olivine and a little less felspar it might perhaps claim a place among the hornblende-picrites, which have been so well described by Professor Bonney, D.Sc., F.R.S.

VI. *Dolerite from Gehat es Shomrah.*

A dark-brown, nearly black, rather fine-grained rock, with large porphyritic crystals of greyish felspar with greasy lustre. The ground-mass, viewed in the microscope, consists mainly of a confused network of felspars, yielding lath-shaped sections, mostly binary twins, with an average size of 0·03 mm. × 0·007 mm. The augite occurs in crystalline grains and small crystalline masses, of brown colour, occupying the spaces between the felspars, and evidently of later consolidation. Indeed, the penetration of the augite by the felspar gives rise to an indistinct ophitic structure. Olivine is present, partly serpentinized, in the form of amber-coloured grains, with here and there a small crystal. One well-marked crystal, of irregular six-sided shape, measured 0·8 × 0·3 mm.; like the other

olivines in the section it contains magnetite along its cleavage cracks and curved fissures. Magnetite is freely disseminated throughout the rock. With a high power crowds of colourless acicular microlites, perhaps apatite, come into view. A little calcite, showing aggregate polarization, is present as a secondary product. No distinct interstitial matter can be detected, and indeed the rock appears to be a holocrystalline dolerite. A porphyritic structure is imparted to the rock by large crystals of felspar, the rectangular sections of which may measure as much as 8 mm. × 2 mm. This felspar shows sharply-defined twin lamellation, and in some sections there are two sets of lamellæ approximately at right angles to each other, thus suggesting that the plagioclase is twinned on both the pericline and albite types. From its high extinction-angles, reaching 40°, it is probably a basic felspar near to anorthite.

VII. *Dolerite from Wady es Shiek.*

A medium-grained, dark-brown rock, much altered, and weathering with a yellow rusty surface. It presents in thin section a dense network of plagioclase in rather thick rectangular sections, with an average size of 1 × 0·25 mm. They inclose dark greenish-brown granular matter, so disposed in some cases as to give a zonal appearance to the sections. Augite occurs in crystalline grains and granular aggregates. The space between the felspars is largely occupied by serpentinous matter, and much of the substance which at first sight looks like interstitial matter is probably a product of alteration. Magnetite is abundant, and scales of red oxide of iron are scattered through the rock. Crowds of minute acicular microlites become visible with a high power.

A re-examination of the diabase, No. 12 in the Appendix, shows that all the quartz is of secondary origin, and hence the rock is simply a diabase with quartz, and not a quartz-diabase. With reference to the felsite, No. 10, it should have been stated that the description applied only to the particular thin section under examination.

I am greatly indebted to Mr. J. J. H. Teall, M.A., F.G.S., and to Mr. T. Davies, F.G.S., for having examined with me some of the sections described in these notes.

VI.—On the Microzoa found in some Jurassic Rocks of England.

By Professor T. Rupert Jones, F.R.S., and C. D. Sherborn, Esq.

In the Geological Magazine, Dec. II. Vol. II. 1875, p. 308, is a list of some English Jurassic Foraminifera, a large number of species being there noted as occurring in these rocks. We have lately received, by the friendly courtesy of the Rev. H. H. Winwood, F.G.S., and Horace B. Woodward, Esq., F.G.S., thirteen specimens of the Jurassic rocks from the south-west of England. One of these has yielded a most important series of Ostracoda. Whilst preparing a special monograph, we hasten to offer some preliminary notes on these interesting Jurassic Microzoa, at present merely noting the

genera, in descending order of strata, and deferring the specific nomenclature for a subsequent opportunity.

1. "Kimmeridge Clay, near Coulston, Wilts." H. B. W.

A mottled (blue and yellow-brown) clay, very stiff and greasy to the touch. Residuum, after washing, a very little, fine, subangular sand, with minute woody fibres. Microzoa rare and very small, of a brown colour and with a sandy appearance. The *Foraminifera* are *Trochammina incerta*; *T.*, sp. near *oligogyra*, Hantken; and another near *gordialis*; *Marginulina* = *Cristellaria Zitteli*, Schwager; *Cristellaria* sp.; *Nonionina*, sp.; *Orbulina neojurensis*, Karrer; and a three-chambered *Globigerina*. These minute fossils are beautifully preserved. No Ostracoda were found.

2. "Clay at the base of the Lower Greensand and on the top of the Corallian; Seend, Wilts. Most likely Kimmeridge Clay." H.B.W.

A pale-grey clay (when dry).

This specimen was washed completely away, leaving neither Microzoa nor sand.

3. "Clay above Iron-ore deposit; Westbury Ironworks, S. of Station. ? Kimmeridge Clay." Rev. H. H. W.

A stiff, mottled, blue clay, with numerous very small, rounded, shining, black concretions.

This left a very small, but rich, residuum of Foraminifera, having a very characteristic Jurassic facies. Amongst the forms are *Lingulina carinata*, var. (this is an oval *Nodosarina*, and, although the mouth appears to be a *circle* of radiating fissures, we think it should be regarded as more Linguline than Nodosarine in character); *Nodosaria*, sp. near *nitidula* (Gümbel, 'Streitberger Schwammlager'); *Dentalina communis*; *Planularia reticulata*; *P. panperata*, narrow, broad, and thin varieties; *Vaginulina cristellarioides*; *V. orthonota*; *V. angustissima*; *V. harpa*, and two others (the first four are figured by Reuss in his 'Norddeutschen Hils und Gault'); *Cristellaria rotulata* with three varieties leading into the next "species," *Cristellaria crepidula*; and *Haplophragmium Canariense*.

These forms are well preserved. No Ostracoda were found.

4. "Yellow Fullers-earth Clay; Midford." Rev. H. H. W. and H. B. W.

This and the following clay are described by Horace B. Woodward in his "Geology of England and Wales" (p. 182) as "a sandy clay, which is described by Mr. Bristow as usually of a greenish-brown or greenish-grey colour, sometimes blue. It is opaque, soft, dull, with a greasy feel, and an earthy fracture." The specimens sent were of a yellow-brown colour.

From the specimen of yellow clay we obtained only two species of Foraminifera, *Cristellaria crepidula* and *Vaginulina legumen*, var.

It is richer, however, in Entomostraca, five species of *Cythere*; two of *Cytherideis*; three of *Cytherella*; and one of *Bairdia*, rewarding our search.

5. "Blue Fullers-Earth; Midford." Rev. H. H. W. and H. B. W.

An indigo-blue clay, drying bluish-grey, extremely rich in Microzoa, especially Ostracoda. It is rather singular that this most

remarkable deposit of Entomostraca has not been noticed before. We have mounted and arranged upwards of three hundred individuals of more than fifty species already, and look for a much larger number before we close our work. The majority of the species were obtained from little more than one pound weight of material. Foraminifera are much scarcer, but there is the same proportionate abundance between the two groups as in the yellow-brown clay above described. A few fragments of shells also occurred, but too imperfect for identification; also ossicles of Pentacrinus, and a few broken minute spines of Echinoderms.

The Foraminifera include a subcarinate variety of *Cristellaria rotulata*, near to one figured by Jones and Parker (Q.J.G.S. vol. xvi. 1860, pl. xx. f. 43); *Cristellaria crepidula*; *Vaginulina legumen*; *Planularia*, sp. near *reticulata*, Cornuel; *Nodosaria lineolata*, Reuss, and *Frondicularia peregrina*, Reuss ('Bohm. Kreide'); and a simple four-rayed star, like the "Siderolina-like forms" figured by Gümbel from the "Streitberger Schwammlager" in "Jahresh. Ver. nat. Württ. 1862, Jahrg. 18, p. 235, pl. iv. f. 19. This little specimen has been shown to Dr. Hinde, who thinks that, although calcareous, it is most likely a modified dermal spicule of a hexactinellid Sponge.

The Entomostraca represent, provisionally, thirty-four species of *Cythere*; three of *Cytherideis*; three of *Cytheridea*; five of *Cytherella*; six of *Bairdia*, also *Cytherura*, *Pontocypris*, *Macrocypris*, and possibly *Aglaia* and *Argillœcia*.

The examination of these forms is affording us very great pleasure, being, though exceedingly small, very finely preserved and perfect. It is interesting to note, that we identify some ten of them as occurring amongst those figured from the Richmond Well in Q.J.G.S. vol. xl. pl. xxxiv.

6. "Loamy beds in Hinton Sand, Forest-marble; Charterhouse-Hinton, Somerset." H.B.W.

A light-brown loam with small "clay galls." This leaves after washing a residuum of fine, subangular, quartzose sand. After careful search we found some extremely small Foraminifera and one Ostracod:—*Cristellaria crepidula*; *Marginulina glabra*; and a valve of *Cythere*.

7. "Bradford Clay; Bradford. This is the clean clay immediately overlying the fossil-bed." H.B.W.

A light-brown clay, which, on washing, left a few waterworn Entomostraca and two *much* waterworn Foraminifera. The latter are *Cristellaria crepidula* and *Vaginulina legumen*; and the former are three varieties of *Cythere*.

8. "Bradford, No. 1. Near Canal. *Locus classicus*." Rev. H.H.W.

No Microzoa found on examination.

9. Bradford, No. 2. Near Bradford. Little higher in position than No. 1." Rev. H.H.W. No Microzoa.

10. "Oxfordian; Upper Studley, Trowbridge. Probably Kellaways Rock." H.B.W.

Dark greenish-brown, friable sandstone of subangular quartzose sand, with calcareous cement. No Microzoa found.

11. "Oxford Clay; Bromham Brickyard. South of Sandridge Hills, between Melksham and Devizes." H.B.W.

A few fragments of shells, but no Microzoa, were found.

12. "Oxford Clay; Upper Studley, Trowbridge." H.B.W.

Very pale, yellowish-grey, sandy clay, yielding after washing, about 50 per cent. of extremely fine, white, subangular, quartzose sand. No Microzoa.

13. "Oxford Clay; Southwick, Trowbridge." H.B.W.

Like No. 12, leaving, after washing, the same remarkably fine, white sand, and presenting no trace of Microzoa.

Note.—Beside the Jurassic specimens we have one from the Cretaceous series of the same district, namely:—"Clay seam in Lower Greensand; Seend." H.B.W.

A ferruginous sandy clay; bound together in places by the iron and forming "pan."

By washing, this specimen yielded abundance of subangular sand, with a little mica.

No Microzoa were met with.

NOTICES OF MEMOIRS.

I.—M. Dollo on the Evolution of the Teeth of Herbivorous Dinosauria.

ALL palæontologists who are interested in the marvellous reptilian life of the Secondary epoch owe a debt of gratitude to M. Dollo of the Royal Museum of Brussels for the ability and care with which he has elucidated the structure and affinity of the unrivalled collection of Dinosaurian and other reptilian remains preserved in that Museum. One of the most interesting of his

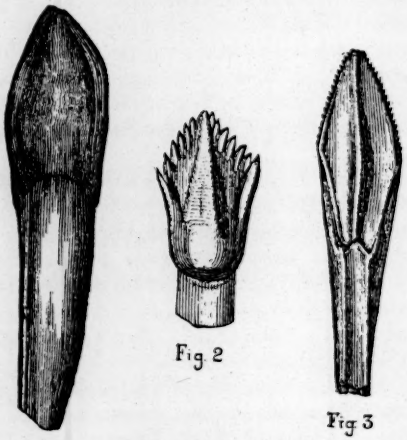


Diagram A.—Fig. 1. Tooth of *Morosaurus*. Fig. 2. of *Scelidosaurus*. Fig. 3. of *Hadrosaurus*.

contributions[1] to our knowledge of the Dinosauria shows how the teeth of the herbivorous members of that order have gradually increased in complexity of structure, and as the author has kindly allowed the use of some of the woodcuts illustrating his memoir, we have great pleasure in laying before our readers a sketch of this line of evolution.

In the generalized suborder Sauropoda, which is mainly Jurassic and died out after the Wealden, we find that the teeth, as in *Morosaurus* (Diagram A, Fig. 1), are perfectly simple, having neither serrated edges, nor carrying ridges on their lateral surfaces. In the generalized Jurassic Stegosauria the teeth still retain the same simple structure, but in the more specialised members of this suborder (e.g. *Scelidosaurus*, Diagram A, Fig. 2), which occur in both the Jurassic and Cretaceous, they have developed serrations on the edges, although not distinct lateral ridges. The next step is presented by certain members of the Ornithopoda, as *Hadrosaurus* (Diagram A, Fig. 3), where a distinct vertical ridge is developed in addition to the serrated edges. Advancing to the more specialised Ornithopoda-like *Iguanodon* (Diagram B), we find that secondary lateral ridges are

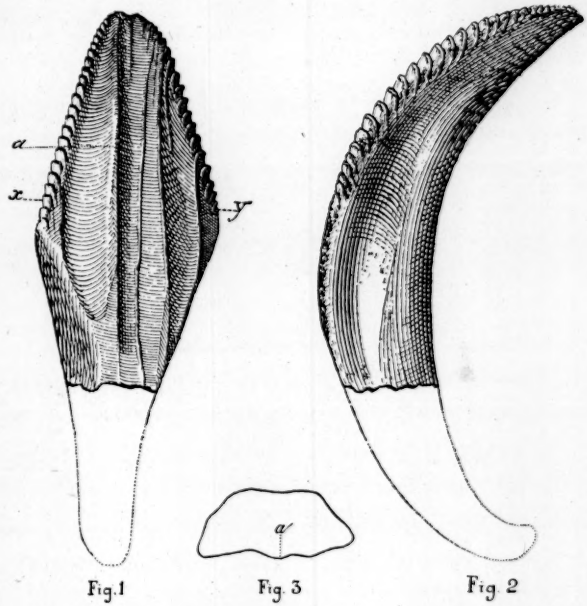


DIAGRAM B.—FIG. 1. Tooth of *Iguanodon Prestwichi*; from the enamelled surface. FIG. 2 in profile. FIG. 3 section from x to y, $\frac{1}{1}$. a shows the principal lateral ridge without serrations.

developed; and we may further observe that while in the Jurassic *I. Prestwichi* both primary and secondary ridges are simple, in the Wealden *I. Mantelli* the former has become serrated. The last step

[1] Ann. Soc. Sci. Bruxelles, 1885, pp. 309–338.

but one is afforded by the remarkable teeth from the Upper Cretaceous (Senonien) described by M. Dollo under the name of *Craspedodon lonzeensis* (Diagram C), in which, in addition to antero-posterior

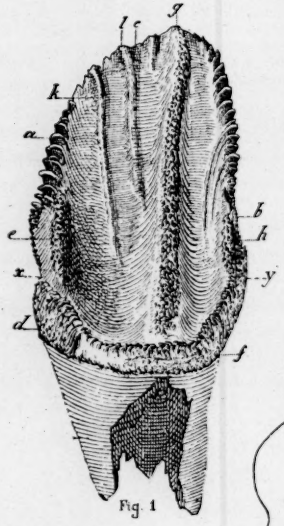


Fig. 1

Fig 3

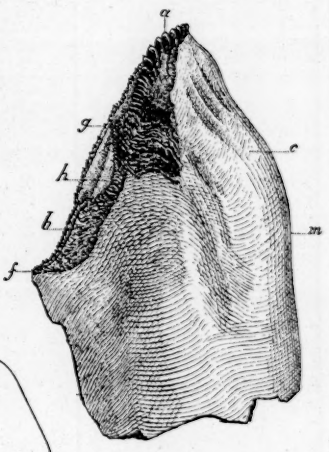


Fig. 2

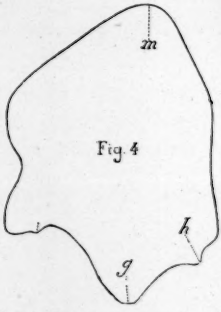


Fig. 4

DIAGRAM C.—Tooth of *Craspedodon lonzeensis*. FIG. 1 from the enamelled surface, $\frac{2}{1}$; *c* crown, *d f* cingulum, the letters *a b e g h k l* indicate the serrations and ridges. FIG. 2 in profile, $\frac{2}{1}$. FIG. 3 the large and small serrations more magnified. FIG. 4 section at *x y*, $\frac{2}{1}$.

serrations, there are primary, secondary, and tertiary lateral ridges, of which both primary and secondary are serrated. Finally the American *Cionodon* simulates the dentition of Ungulate Mammals in having numerous cheek-teeth in use at one and the same time.

M. Dollo concludes this interesting survey by observing that "it appears that while the specialization of the dentition in the Ungulata has taken place either by the development of infoldings in the enamel (*Equidæ*), or by the multiplication of tubercles (*Suidæ*), accompanied by gradual elevation of the crown, it has manifested itself in the herbivorous Dinosauria by the development of ridges and serrations, or by the simultaneous use of numerous teeth. While, however, the cause of the evolution of the dentition of the Ungulata is, so to speak, known to us, we can only guess at that of the dentary system of the great Reptiles which filled their place during the Secondary epoch."

R. LYDEKKER.

II.—Emmons' Original Taconic Series.

1. On Lower Silurian Fossils from a Limestone of the Original Taconic of Emmons. By J. D. Dana.

2. Preliminary Report of S. W. Ford and W. B. Dwight upon Fossils obtained in 1885 from Metamorphic Limestones of the Taconic Series of Emmons, at Canaan, New York. American Journal of Science, vol. xxxi. p. 241—253, pl. vii. April, 1886.

PROFESSOR DANA points out that the *original* and therefore *true* Taconic system of Prof. Emmons, which this geologist propounded and described in 1842, "lies along both sides of the Taconic range of mountains, whose direction is nearly north and south, or, for a great distance, parallel with the boundary-line between the State of New York and those of Connecticut, Massachusetts, and Vermont." Emmons described it as consisting of (1) "Taconic slates" in eastern New York, including the Hoosie slates; (2) the Sparry or western limestone, interstratified with the slates, west of the Taconic range, and for the most part lying against the west side of the range; (3) the "talcose" or "magnesian" schist, constituting the Taconic range, and Greylock or Saddle Mountain, the high ridge between Williamstown and Adams in the north-western angle of Massachusetts; (4) the Stockbridge Limestone, east of the range of Taconic schist; (5) Quartzite. Prof. Emmons concluded, on lithological grounds, that the system was older than the New York Potsdam Sandstone, and equivalent to the Lower Cambrian of Sedgwick. Subsequently, in Washington County, New York, outside the typical area of the Taconic system, Emmons discovered, in black slates, some Trilobites, pronounced by Barrande to be *Primordial* species. These black shales were regarded as more recent than the typical rocks, in which no fossils whatever had been discovered, and Emmons called them therefore Newer or Upper Taconic.

But now recently fossils have been discovered in the Sparry or Western Limestone, the oldest limestone of Emmons' original Taconic, and in a locality in the typical area of the system. The fossils are very fragmentary, and can only be examined by means of thin sections and polished surfaces of the rock. They show, however, the presence of distinct species of *Murchisonia*, *Pleurotomaria*, and *Fenestella*, as well as portions of Crinoids, probably of Brachiopods, and of a Trilobite. Prof. Dwight and Mr. Ford, who have studied the fossils, believe that they indicate the Trenton age of the limestone in which they are preserved.

It follows from this discovery that the age of the typical Taconic system of Emmons is not Cambrian or Pre-Cambrian, as stated by him, and that the black shales and limestones with Primordial Trilobites, forming his Newer or Upper Taconic system, really belong to a period much older than the so-called Lower Taconic. G. J. H.

REVIEWS.

Geological Survey of S. Australia.

Report on the Geological Character of Barossa and Para Wirra, South Australia.

Notes, etc., Explanatory of Parliamentary Paper No. 178, with a Geological Map of Pira Wirra and Barossa Reserves. By Henry Y. Lyell Brown, F.G.S., Government Geologist, assisted by Harry Page Woodward, F.G.S. Folio. (Adelaide, 1886.)

The Barossa and Para Wirra Goldfields.

The Barossa goldfield is situated in the south-west corner of the hundred of that name; it is separated from the Humbug Scrub goldfields only by the South Para River, which latter is also included in the map. It was discovered in October, 1868, by Job Harris and mates, who found gold in the gully now known as Spike gully. This gully is about one mile and a half long—the prospector's claim being near the middle.

The depth of sinking was from 5 ft. to 20 ft., and some of the claims were very rich, yielding as much as £1000 per man.

The general features are a main rocky range, running from north to south, of which Mount Gawler, near the south end, attains a height above the sea of 1789 ft. This range is flanked on either side by patches of Tertiary deposits, on the spurs between which the gullies descend gently into Malcolm's Creek on the east, and through steep rocky gorges into the Little Para, Gould's and Tenafeate Creeks on the west. The north end of the reserve, in Barossa, is divided from that in Para Wirra by the deep rough gorge of the South Para River. Here the main ridge runs north-west and south-east, following the course of the river, and being capped on its highest part by Tertiary beds, with its small steep gullies running south into the Para River, and north down a gentle incline into the Yetti Creek.

The rocks of this district are supposed to be of Lower Silurian age, from their lithological resemblance to those of the Victorian goldfields, although from their highly metamorphic appearance, and no fossils having been found, it is impossible to say decidedly of what age they are. In several places intrusive granite dykes are met with, and in one particular line, from Malcolm's Creek to Mount Gawler, they are very frequent.

These rocks consist of metamorphic argillaceous and micaceous schists, slates, sandstones and grits, granite, gneiss, hornblende schists, mica schist and quartzites with granite, greenstone, and felspathic dykes. As a rule they have a uniform strike of about 20° east of north, and dip to the eastward from 35° to 70°; the only exception to this rule seems to be near the Bismarck diggings, where the dip is 70° west in two places; but this is probably caused by local agency, as it does not extend far.

Nearly all the rocks of this district, especially on the ridges, have so highly weathered an appearance, and are so decomposed, that they might often be taken for Tertiary cements, particularly some coarse-grained metamorphic granites, which contain a great deal of iron. The

only place where the rocks are not highly altered is along the Yetti Creek, where they consist of sandstones and slates.

Pliocene Leads, Deep Leads, or made ground.—During the Tertiary period, the main range was already elevated considerably and two main streams flowed, one on each flank, into which small gullies probably ran. Both these creeks flowed north, as is proved by the level of their old beds descending in that direction. The one on the east side seems to have risen somewhere near Mount Gawler, thence flowing in a northerly direction, its course being now traced by a few out-lying patches of made ground, and by a general line of low country crossing the present creeks.

The other had its rise somewhere to the southward, and passed on the west side of Mount Gawler, and flowed northward towards the Humbug Scrub, where, at the head of Leg of Mutton Gully, it was joined by the eastern stream. Thus increased in size, it flowed across the present river to the Barossa goldfield, and so on in a north-westerly direction to Gawler, where it discharged itself into the sea. This is deduced from the position of outlying patches of Tertiary gravel, sand, and clay (marked yellow on the map), which have escaped denudation.

These deposits constitute the old gold drifts from which a considerable amount of gold has been obtained in Barossa, and a small amount in Para Wirra. As the payable portion of these gold drifts can only be ascertained by sinking shafts—often through hard conglomerate, the gold occurring in gutters beneath—a considerable amount of labour has to be performed before a run of gold is struck; in consequence, a large area consisting of patches of this Pliocene Tertiary has not yet been prospected by the gold miner. Here and there a hole has been put down, but only in a random manner; and the ground still remains unproved.

The patches of old gold drift, which are known as "made hills," are generally characterized by ferruginous sandstone and conglomerate capping, called cement, which being very hard, has protected the softer beds of sand, pipeclay, and gravel, from being washed away.

In some cases the lower beds have been cemented, in which case crushing mills had to be employed to obtain the gold.

Para Wirra Gold Reefs.—General Notes.

The Lady Alice reef has only been worked to a depth of about 160 ft., and is well worth being farther prospected below that level, considering the richness of the stone already raised and the shallow depth from which it was obtained.

The various reefs and veins which are at the present time being prospected on the Young Australian property show good prospects of gold on and near the surface. They are worthy of a more systematic and extensive examination by means of shafts.

An examination of the map will show what a comparatively small area of that occupied by Tertiary deposits of older gold-drift has been prospected for gold. Shafts have been sunk here and there. Some of these have not been bottomed, *i.e.* have not reached the bed-rock; others have bottomed on high ground, and the run of gold has not been immediately struck, consequently operations have been suspended

forthwith. Some of the gullies between the patches of older gold-drift should be prospected for gold washed out of the "lead" across the course of which they have been eroded. Where these gullies are deeply cut into the bed-rock, an opportunity is afforded of testing the junction between the bed-rock and the Tertiary drift by drives or tunnels. In other places, where the country is flat, trial shafts will be necessary to prove the auriferous nature of these deposits.

The bed of the South Para River should contain payable alluvial gold, as a large area of Tertiary gold-drift, which at one time was continuous, from Para Wirra into Barossa, has been denuded by the river, and the gold it contained sluiced down and re-deposited in its valley.

Mr. Selwyn, in his "Geological Notes of a Journey in South Australia from Cape Jarvis to Mount Serle," in 1859, recommended the testing of parcels of quartz from the reefs, and a search for gold in the Tertiary gravels of the Mount Crawford district, ten years before gold was found.

The information referring to the history of the diggings, depth of shafts, etc., has been obtained from Messrs. Goddard, Barkla, Dawes, Turner, Trenowden, Smith, and Bayley, residents of the district. That relating to the yield of gold and copper from the Lady Alice mine has been supplied by Mr. W. R. Lewis, who was secretary to the company from 1873 to 1879, and Mr. G. C. Faid.

The Report contains a summary of the results of all the gold workings in both the Barossa Gold-reefs and those of Para Wirra, and is accompanied by an excellent map, prepared by H. P. Woodward, F.G.S., Assistant Government Geologist. The Report is dated December 10th, 1885.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—April 21, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "On a certain Fossiliferous Pebble-band in the 'Olive group' of the Eastern Salt Range, Punjab." By A. B. Wynne, Esq., F.G.S.

The principal object of this paper was to oppose the views recently published by Dr. Waagen as to the age of certain boulder-beds in the Salt Range of the Punjab. By that author these beds had been considered contemporaneous with each other, and assigned to the epoch of the Coal-measures, in consequence of the discovery by Dr. Warth of Carboniferous fossils, especially Australian forms of *Conularia*, in nodules restricted to a particular layer in the upper part of a boulder-bed in the eastern Salt Range. Mr. Wynne adduced evidence to show that the fossils in question occur, not in concretions, as supposed by Dr. Waagen, but in pebbles evidently derived from an older series; and consequently there was no proof that the boulder-bed in question was older than the Cretaceous Olive beds with which it had hitherto been associated.

The principal boulder-beds in the Salt Range were then briefly

noticed; those beneath the Carboniferous Limestone west of the Indus, those near Amb and Sakesir peak, associated with the "purple sandstone," "*Obolus*-beds," and "speckled sandstone," and those in the eastern portion of the Salt Range, amongst the beds of the "Salt pseudomorph zone" and "Olive group," being successively passed in review, and their relations to overlying and underlying strata explained. It was shown that boulder-beds and conglomerates containing pebbles and boulders of the same crystalline rocks are not confined to one horizon.

In conclusion, the resemblance of the rock, of which the pebbles containing *Conulariæ*, etc., were formed, to that forming some of the "magnesian sandstone" and "*Obolus*-beds," was pointed out, and it was suggested that the pebbles in question may have been derived from representatives of those beds formerly existing to the southward.

2. "On the Phosphatic Beds in the Neighbourhood of Mons." By M. F. L. Cornet, For. Corr. G. S.

The beds are situate in the province of Hainaut, near the town of Mons (Belgium); the workings have increased of late years, and in 1884 yielded 85,000 tons of phosphate.

They occur in the Upper Cretaceous, which is exceptionally well developed in the district, filling a trough in the Carboniferous rocks, and itself denuded for the reception of Tertiary and Quaternary beds.

Omitting all Cretaceous groups below the middle of the fifth stage, the following is the sequence of the Cretaceous beds which contain the phosphatic series:—

C. Tufaceous Chalk of Ciply, with the Poudingue de la Malogne at its base.

D. *Brown Phosphatic Chalk of Ciply.*

E. Coarse chalk of Spiennes.

F. White chalk of Nouvelles.

F is a pure white chalk with some flints and contains *Belemnitella mucronata, Rhynchonella octoplicata, Terebratula carnea, Ananchytes ovatus*, etc.—an horizon well known throughout North-western Europe. Series E and D represent one geological horizon, characterized by *Ostreæ*, Brachiopoda, etc., in great numbers, but also containing *Belemnitella mucronata*, and lying between two distinct planes of erosion.

The Brown Phosphatic Chalk (D), which forms the Upper division of the series, is about 70 feet thick, and may be described as consisting of three parts; the upper is tolerably pure carbonate of lime, but in its lower portion becomes charged with brown granules mainly consisting of phosphate of lime; these continue to increase towards the central or main phosphatic mass, which is also highly fossiliferous in places. This central portion constitutes the main phosphatic beds, but the amount of phosphoric acid (dry) is not more than 12 per cent.

Hence, it is necessary to increase the richness in phosphate of the deposit in order that it may be available for conversion into a superphosphate. This may be done by mechanical means.

But nature has already partially anticipated this process, and the

result has been a deposit known as "rich phosphate," containing about 25 per cent. of phosphoric acid. This occurs in wide cracks and holes in the ordinary phosphatic chalk. It usually occurs as a fine sand-like powder, and is evidently the result of the action of carbonated waters upon the phosphatic chalk, whereby the amount of carbonate of lime is reduced. This is especially the case where the phosphatic chalk is not protected by the tufaceous chalk of Ciply, but is only covered by Tertiary or Quaternary beds.

The author calculates that each square foot of the phosphatic basin, which he estimates approximately at five miles by three, contains 355lbs. of tribasic phosphate of lime. Finally he estimates how the phosphatization of the chalk may have been brought about.

II.—May 12, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Maxilla of *Iguanodon*." By J. W. Hulke, Esq., F.R.S., F.G.S.

Two fragments, together representing nearly the entire left maxilla of a species of *Iguanodon*, have been found at Cuckfield, the locality whence the first tooth of the genus was obtained by Dr. Mantell, about 1820. These fragments, measuring together 29 centimetres, and exhibiting 19 alveoli in the dentary border, were described in the paper. It was shown that the upper jaw in question probably belonged to *Iguanodon Mantelli*. In addition to the detailed characters described, the maxillæ of *Iguanodon* and *Hypsilophodon* were compared, and their distinctions explained.

2. "Notes on the Distribution of the Ostracoda of the Carboniferous Formations of the British Isles." By Prof. T. Rupert Jones, F.R.S., F.G.S., and J. W. Kirkby, Esq.

Although all the Ostracoda of the Carboniferous formations are not yet described, there are 170 species and notable varieties known, belonging to 33 genera of 9 families. About 25 of these species, not yet described, but determined by the authors, are introduced into their lists as giving a fuller idea of the value of this manifold Crustacean group.

In the first place they referred to the classification of the Carboniferous strata in Scotland and in England, according to the local differences, taking in succession "Scotland West," "Scotland East," "England North, with the Isle of Man," "England Central and South, with South Wales," as the several districts from which they have obtained good groups of Ostracoda from different members of the Carboniferous series.

In Fife, the lowest local Carboniferous strata contain *Beyrichia subarcuata;* higher up come in *Carbonia fabulina, C. Rankiniana, Bairdia nitida* and *Leperditia Okeni;* the last, accompanied by other species, occurs throughout this lowest series, in which the record is more complete than in Midlothian and Linlithgowshire, where the same species also occur. In Dumfriesshire and Ayrshire *Leperditia Okeni* and *L. subrecta* have been found in beds even lower than the above mentioned, and are therefore probably the oldest Carboniferous Ostracoda; other species accompany them higher up, and in Roxburghshire some localities

of the Carboniferous-sandstone series are very rich in species. The Carboniferous-Limestone series of S.W. Scotland has been highly productive of Ostracoda, particularly the shales of the lower beds; 36 species are common or characteristic. The middle or coal-bearing portion has yielded but few, chiefly *Leperditia Youngiana*, one *Beyrichia*, *Carbonia fabulina*, and *C. Rankiniana*. The Upper-Limestone group contains many recurrents from below and a few others, including *Youngia rectidorsalis* (MS.). The Millstone-Grit equivalents have no Ostracoda; but the overlying Coal-measures are rich in *Carboniæ*, with a few others, such as *Cypridina radiata*.

A great variety of genera and species come from beds at or near the base of the Scar Limestone and its equivalents in North Lancashire, Westmoreland, Cumberland, and Northumberland. The Calcareous shales of the Yoredale have several interesting forms, including *Phreatura concinna* (MS.); none from the Millstone-Grit.

The Lower Coal-measures give *Beyrichia arcuata* and *Carbonia*, sp. The middle beds have *B. arcuata* and *Carbonia fabulina*, common; rarer, *C. Rankiniana*, *C. secans*, *C. scalpellus*, *C. Wardiana* (MS.), and *Philomedes elongata*. In the Upper Coal-measures *B. subarcuata* reappears; and in the *Spirorbis*-limestone *Leperditia inflata* is the latest Carboniferous Ostracod in England.

In Northamptonshire the deep Gayton boring (at 730 feet) has given *Kirkbya variabilis*, *K. plicata*, *Bythocypris sublunata*, *Macrocypris Jonesiana*, *Cytherella extuberata*, and *C. attenuata*, all but one belonging to the Lower-Carboniferous series. In Salop, South Wales, and Somerset the Carboniferous Limestone has yielded several good species of *Leperditia*, *Kirkbya*, *Moorea*, *Bythocypris*, *Bairdia*, etc. *Carbonia Agnes* and *C. Evelinæ* belong to the South-Welsh Coal-measures.

The distribution of the Carboniferous Ostracoda in Ireland requires further work; but the Lower-Carboniferous Shales and the Mountain Limestone near Cork and elsewhere are very rich, as are also some parts of the latter in the Isle of Man.

The Ostracoda of the Permian formation were then treated of in relation to their Carboniferous allies, and the range of the British Carboniferous Ostracods in Europe and North America was noticed in some detail.

The results of the examination were shown in two extensive tables.

3. "Note on some Vertebrata of the Red Crag." By R. Lydekker, Esq., F.G.S.

This communication contained briefly the results of a re-examination of the specimens from the bone-bed of the Red Crag in the British and Ipswich Museums, a series of casts from the latter having been added to the former. The forms noticed were *Hyæna striata*, with which *H. antiqua* and *H arvernensis* were considered probably identical; *Mastodon*, of which the author thought three species, *M. arvernensis*, *M. longirostris* and *M. Borsoni*, were represented; *Sus*, of which two forms, the larger probably *S. erymanthius* or *S. antiquus*, the smaller *S. palæochœrus*, had been detected; a Tapir, which was probably *Tapirus arvernensis* or *T. elegans* rather than *T. priscus; Hipparion gracile;* a *Rhinoceros* referable to the hornless *R. incisivus* rather than to *R. Schleiermacheri*, though the latter probably also

occurred; a species of Albatross (*Diomedea*) represented by a right tarso-metatarsus, and the associated proximal phalangeal bone of the fourth digit.

4. "The Pleistocene Succession in the Trent Basin." By R. M. Deeley, Esq., F.G.S.

The author, after referring to the previous publications on the subject, proceeded to notice the leading characters of the greatly developed Pleistocene deposits in the area drained by the Trent river and its tributaries. He proposed to classify the beds in question under three divisions, comprising the following stages. The beds of the lowest division were distinguished from those of the middle and upper by the absence of Cretaceous rock-débris.

Older Pleistocene.	Early Pennine Boulder-clay. Quartzose Sand. Middle Pennine Boulder-clay.
Middle Pleistocene.	Melton Sand. Great Chalky Boulder-clay. Chalky Sand and Gravel.
Newer Pleistocene.	Interglacial River-alluvium. Later Pennine Boulder-clay.

Each of the stages was then described separately, with details of exposures and sections throughout the area.

The Early and Middle Pennine Boulder-clays, which closely resembled each other, were regarded as composed of materials derived almost entirely from the Derbyshire mountains, but with a slight admixture, to the westward, of erratics derived from Scotland and Cumberland. The latter were probably brought from those counties by an ice-stream, the main materials of the deposits having been transported from the Pennine chain by glaciers, and deposited in the partially submerged valley of the Trent. The intermediate quartzose sand was deposited in the sea during an intercalated warmer age of considerable submergence.

The Middle Pleistocene deposits, distinguished from the earlier by containing large quantities of chalk and flints derived from the north-east, were apparently formed at a time when the level of the Trent-valley area was lower than that of the Cretaceous tracts in Lincolnshire and Yorkshire. The Great Chalky Boulder-clay was chiefly a ground-moraine formed beneath an ice-sheet on land, but in places presented signs of aqueous origin. The Melton sand, below, in which Cretaceous detritus first appeared in abundance, consisted of stratified sands with occasional beds of gravel or loam, and indicated a less extreme temperature. In West Staffordshire the gravels and sands probably represented the entire Middle Pleistocene deposits, no great Chalky Boulder-clay being found, and in this area fragments of marine mollusca were of frequent occurrence. The Chalky Gravel was also a marine deposit, and, like the Melton Sand, was probably formed when the temperature was rather milder than it was during the deposition of the Great Chalky Boulder-clay.

In the Newer Pleistocene epoch re-elevation of the Trent valley and of the Pennine chain appeared to have again produced a change in the direction from which the materials of the deposits were derived. The

Interglacial Alluvium was of freshwater origin, but the admixture of Scotch and Cumbrian detritus with that derived from the Pennine range indicated that glaciers from the north again reached the Trent area. A colder age succeeded, during which the Later Pennine Boulder-clay was formed, partly of local materials, partly of erratics from the Pennine range, mixed with a few from Cumberland and even from Wales. This deposit was almost entirely unstratified, and consisted largely of moraine detritus, the ice-sheets having disturbed and rearranged the earlier deposits and mixed them with rock-detritus from the neighbourhood. To this later ice-sheet was attributed the contortion so frequently observed in the Older and Middle Pleistocene deposits. Reasons were given for the opinion that such contortions were due to ice- and not to soil-cap motions or their later agencies.

5. "On the Existence of a Submarine Triassic Outlier in the English Channel off the Lizard." By R. N. Worth, Esq., F.G.S.

Attention was called to the frequent occurrence of sandstone fragments in a certain part of the English Channel, brought up by the fishermen's "long lines." The evidence favours the idea that these rocks are *in situ*.

A list of the specimens found, with bearings and distances, was given; they consist of red, and sometimes greyish sandstones, mostly soft, also marls, "potato stone," and nodules of Triassic trap. The affinities are with the Keuper of Devon. The position deduced from the observations is about 10 miles S.E. of the Lizard, and beyond the 30-fathom line. This submarine outlier is larger than any outlier on the mainland of Devon or Cornwall, and carries the English Trias nearly 50 miles further to the S.W.

Zoological Society of London.

April 20th, 1886.—Prof. W. H. Flower, LL.D., F.R.S., President, in the Chair.—The following communication was read:—

3. "On the Relations of the Mandibular and Hyoid Arches in a Cretaceous Shark (*Hybodus dubrisiensis*, Mackie)." By A. Smith Woodward, F.G.S. Communicated by the Secretary.

In this paper, the author described the mandibular and hyoid arches of *Hybodus dubrisiensis*, as exhibited in a fossil from the Chalk of Kent, preserved in the British Museum. The cartilages are all in an admirable state of preservation, and show that the Cretaceous Hybodont skull made a near approach to the primitive condition termed "amphistylic" by Prof. Huxley (Proc. Zool. Soc. 1876, p. 41). The fossil jaws are also interesting from their close resemblance to those of the Notidanidæ, which are the most amphistylic of living vertebrates; and the pterygo-quadrate cartilage exhibits the facette for a post-orbital articulation with the cranium, which forms so characteristic a feature of the existing family just mentioned. The hyoid elements are likewise remarkably slender. The fossil further shows traces of well-calcified vertebræ, which are astero-spondylic in structure, and are well seen in a second specimen in the National Collection. The latter fact is of peculiar interest, since a fossil from the Lias, with teeth generically indistinguishable,

affords distinct evidence of a persistent notochord, with the arches alone calcified; and as three Hybodont pterygo-quadrates of Liassic and Wealden age appear to be destitute of an articular facette where contiguous with the post-orbital region of the cranium, there is also a corresponding indication of progressive development in the mandibular arch. The author also pointed out that the differences between the anterior and posterior teeth are more marked in *H. dubrisiensis* than in any of the earlier forms of which satisfactory remains are known, and concluded by suggesting that future research in regard to structures other than teeth will probably lead to the generic subdivision of the multitudinous forms hitherto grouped under the name of *Hybodus*.

CORRESPONDENCE.

THE SURVEY OF WESTERN PALESTINE.

Sir,—Permit me to offer two or three observations as regards matters of fact in reply to the criticisms contained in the review of the "Geological Memoir on Arabia Petræa and Palestine." The reviewer says (p. 229): "Fossils appear to be rare throughout the [Cretaceo-Eocene] series—the Expedition does not seem to have discovered any in fact." This is really not so. We brought home a good many specimens, and I placed them in the hands of Professor Sollas (who was so good as to describe the Carboniferous forms) for determination. But owing to causes, doubtless quite sufficient, I did not receive the specimens back till too late for publication. Since then Prof. Sollas has informed me that there were no new forms amongst them, as they had already been determined by Lartet and others. It is only known to those who have made the attempt, how difficult it is to collect fossils and specimens when on a journey on camel- or horse-back, through the desert under a temperature of 80° Fahr. in the shade, and 112° in the sun.

Again, in speaking of the "*Calcareous Sandstone of Philistia*," the reviewer states, "No thickness is assigned to this deposit." I have only to say in reply that owing to the extent to which Philistia is overspread by the deposits of the 220 raised sea-bed—and with loam—the sections of this sandstone are very rare; nor had we any opportunity of observing the junction of the sandstone with the Nummulite-limestone. Both thickness and relations, as they are inferred by me, may be gathered from the horizontal section, No. 1, across Palestine. It is not improbable the formation has a thickness of 300 to 400 feet. The reviewer seems to have overlooked the fact that this sandstone appears to have its equivalent in the series at Mokattam Hill, near Cairo, described by Schweinfurth.

3. As regards the question, "What has become of the materials which have been removed from the surface of the drainage area of the Dead Sea?" (p. 231). As this basin never had an outlet, there can be only one answer (which appears to me self-evident)—that they are either used up in the terraces—or are spread over the floor of the Dead Sea and Jordan-Arabah Valley. The bottom both of

the Dead Sea and of this valley are covered by alluvial deposits. What the thickness of these may be no one knows; nor can the question of the depth to the *solid rocks* below the alluvial materials be solved except by extensive boring operations. In my opinion the depth is very great; and if this be so, the answer to the question of the reviewer is plain,—at least, this is the only answer I conceive possible.

DUNFANNAGHY, 12*th May*, 1886. EDWARD HULL.

THE DEVELOPMENT OF THE NORTH AMERICAN CONTINENT.

SIR,—There are no questions in Geology more important and more fascinating than those of Palæo-geography. All geologists must be grateful to Prof. Hull for the light he has shed upon them. But, also, there are no questions which are more difficult, and the solution of which is more illusory. I would not again trouble you on this subject except to correct what seems to me a grave misconception on the part of Prof. Hull,[1] which lies at the basis of nearly all the difference between us.

He refers to an ideal section of the Palæozoic rocks on p. 288 of my "Elements of Geology" (being a section from Canada through New York to Pennsylvania), as indicating continued *subsidence* of sea-bottom and *retreat of shore-line northward* during the Palæozoic period. This interpretation is the very opposite of that usually given by American geologists. Perhaps the mistake, if it be one, is partly due to bad drawing. In order to bring all the Palæozoic strata within the compass of a small figure, the southward dip is enormously exaggerated. In fact, the strata are nearly level, the average dip being probably not more than 15–20 feet per mile. The successive appearance of younger and younger rocks as we go southward is supposed by all American geologists to indicate a gradual *elevation* of the Canadian land-mass of that time, and a consequent *advance of the shore-line southward with steady increase of land.* This is seen at once if the section be drawn with smaller dips and leaving out details (Fig. 1).

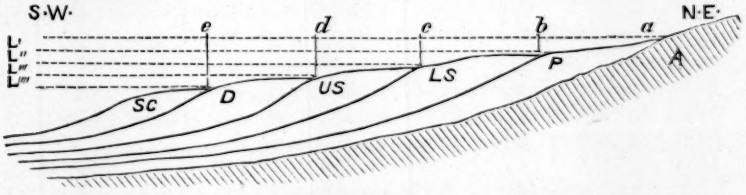


FIG. 1.—Generalized N.E. and S.W. section from Canada through New York to Pennsylvania. *A.* Archæan. *P.* Primordial. *L.S.* Lower Silurian. *U.S.* Upper Silurian. *D.* Devonian. *S.C.* Sub-Carboniferous. *a b c d e* successive shore-lines. *l' l'' l''' l'''' l''''* successive sea-levels.

The western shore-line of the *eastern* land-mass was, on the contrary, nearly stationary, and hence the prodigious thickness of Palæozoic sediments in the Appalachian region. Even here, however,

[1] See Prof. Hull's letter, GEOL. MAG. April, 1886, p. 189.

whatever movement of shore-line there was, seems to have been westward with increase of land.

Two other points I briefly touch. Prof. Hull thinks that I do not recognize sufficiently, if at all, his most important point, viz. "the increase of thickness of sediments to the N.E. and E., and their attenuation and replacement by limestone in the opposite direction." If I did not lay stress on this, it was only because I supposed it generally recognized, although Prof. Hull brings it out in a very striking way in his figures. No one has emphasized these facts, and their significance as showing a large land-mass to the north-east and a wide ocean to the south-west, more than I have.[1]

Again, in my previous communication[2] I said, "There is no reason why the eastern land-mass, which sufficed to contribute 30,000 ft. of Silurian and Devonian sediments, should not have been sufficient to contribute the much smaller amount of Carboniferous sediments." Prof. Hull thinks this a begging of the question at issue. For, says he, "the narrow strip of land allowed by Prof. Le Conte was quite insufficient to produce 30,000 ft. of conformable sediments." I can only say in reply that Prof. Hull's map of Silurian times led me astray: for this shows just such a land-mass as I suppose, while his map of Carboniferous times shows a very much greater land-mass. I suppose, now, however, that he imagines this land-mass to have increased on its eastern side through Silurian and Devonian times. If so, it must have increased very rapidly, for the Silurian alone is 20,000 ft. thick in the Appalachian region. JOSEPH LE CONTE.

PERMANENCE OF CONTINENTS & OCEAN-BASINS, WITH SPECIAL REFERENCE TO THE FORMATION AND DEVELOPMENT OF THE NORTH AMERICAN CONTINENT.[3]

SIR,—Will you allow me to make a correction? Prof. Chamberlin has kindly drawn my attention to the fact that in my original communication to you on this subject[3] I have misrepresented him, and I wish therefore to acknowledge my error. The map on p. 62 of Prof. Chamberlin's work on the Geology of Winconsin was not intended, as I supposed, as a map of Archæan areas, but really as a map of land during a portion of Archæan times, viz. (if I understand him) at the beginning of the period of Huronian sedimentation. I was misled by its great resemblance to the usually recognized map of Archæan areas. The confusion of thought to which I referred does indeed exist, but Prof. Chamberlin is not an example of it.

Let us hope that Prof. Chamberlin will give us more fully his mature views on this so obscure and yet so important subject. No one is more competent than he to write with authority on the subject. JOSEPH LE CONTE.

BERKELEY, CALIFORNIA, *May* 3, 1886.

[1] Am. Jour. vol. iv. p. 463, 1872. Elements of Geol. p. 289.
[2] See GEOL. MAG. March, 1886, p. 100.
[3] GEOL. MAG. 1886, Dec. III. Vol. III. p. 97.